AUG 1956
LIBRARY
POFI
FISH & WILDLIFE
SERVICE

EXPEDITION REPORTS

Q115
C4
V.5
Pt.2

Gt. Brit. Chall. Off.
Rept. scient.results...

Zoology

Vol.5,pt.2

1882

LIBRARY
BUR. OF COMM. FISH.
HON. BIOL. LAB.

Case
Shelf F.
18814

٢٠٧٤

LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH

DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY, F.R.S.E.

ONE OF THE NATURALISTS OF THE EXPEDITION

BUREAU OF FISHERIES
No. 24397

1367

ZOOLOGY—VOL. V.

PART XVI.—REPORT ON THE MARSUPIALIA

Published by Order of Her Majesty's Government

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE

AND SOLD BY

LONDON:—LONGMANS & CO.; JOHN MURRAY; MACMILLAN & CO.; SIMPKIN, MARSHALL, & CO.
TRÜBNER & CO.; E. STANFORD; J. D. POTTER; AND KEGAN PAUL, TRENCH, & CO.
EDINBURGH:—ADAM & CHARLES BLACK AND DOUGLAS & FOULIS.
DUBLIN:—A. THOM & CO. AND HODGES, FIGGIS, & CO.

1882

Price Twelve Shillings,

17 C°

LABORATORY
FISH & WILDLIFE
PACIFIC OCEAN
INVESTIGATIONS

PRINTED BY NEIL AND COMPANY, EDINBURGH,
FOR HER MAJESTY'S STATIONERY OFFICE.

NOTE.

In the lists of the Challenger Reports which have hitherto been published, this paper has been entitled "Report on the Marsupialia," but this name does not quite correctly indicate its true character.

Shortly after the return of the Challenger to England, one or two scarce Marsupials were handed over to Dr. (now Professor) D. J. Cunningham for anatomical examination.

While engaged in the study of these species, Professor Cunningham found it necessary, so far as the foot was concerned, to push his inquiries into the Mammalia generally; and to assist him in this more extended investigation, a considerable number of other Mammals, collected by the Challenger in various parts of the world, were placed at his disposal for dissection.

In this way what was originally intended to be limited to a Report on the Anatomy of a few rare Marsupials, now embraces in addition a valuable research on the Comparative Anatomy of the Mammalian foot.

This paper was received March 28, 1882.

JOHN MURRAY.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

1367

REPORT on some points in the Anatomy of the Thylacine (*Thylacinus cynocephalus*), Cuscus (*Phalangista maculata*), and Phascogale (*Phascogale calura*), collected during the Voyage of H.M.S. Challenger in the years 1873–1876; with an account of the Comparative Anatomy of the Intrinsic Muscles and the Nerves of the Mammalian Pes. By D. J. Cunningham, M.D., F.R.S.E., Professor of Anatomy in the Royal College of Surgeons in Ireland.

In March 1877 I received from Sir C. Wyville Thomson, for purposes of anatomical research, all the Marsupial animals brought home by the Challenger Expedition. The collection comprised the following specimens:—

Four	specimens	of the	*Phalangista vulpina.*
Three	„	„	*Dasyurus viverrinus.*
Two	„	„	*Thylacinus cynocephalus.*
One	„	„	*Phalangista maculata.*
One	„	„	*Phascogale calura.*

Of these I chose for special examination the *Thylacine*, the *Cuscus*, and the *Phascogale*. In this choice I was influenced by the fact that these three species are the least known, and represent types which differ widely from each other, both in physique and habits. The other specimens I merely used for purposes of comparison, and am not prepared, therefore, to give a detailed account of their anatomy even were this advisable.

Both specimens of *Thylacinus* were sent to the Challenger Expedition while at Sydney, by Sir Charles Du Cane, K.C.M.G., the then Governor of Tasmania. The one was a large male, the other a female very much smaller in size. The following were the measurements:—

Male.	Ft.	in.
From the tip of the nose along the back to the root of the tail, . .	3	3
Length of tail, ...	1	8½
Female.		
From the tip of the nose along the back to the root of the tail, . .	2	7
Length of tail, ...	1	4

The male had manifestly been received in a very putrid state, but its long immersion in strong spirit had considerably improved its condition. The female was in an admirable state of preservation, and it is consequently from it that the majority of the drawings have been taken and the description framed. A special interest is attached to the anatomy of this animal, from the very prevalent belief that the genus of which it is the sole member is rapidly becoming extinct. Thus Owen,[1] writing in 1842, speaks of it as a species "whose term of existence seems fast waning to its close."

The *Cuscus* was obtained in New Guinea, and was presented to Sir Wyville Thomson, while on a visit to Queensland, by Mr. Sheridan of Maryborough.

In my examination of the intrinsic muscles of the marsupial manus and pes, I was met by a somewhat puzzling multiplication of the elements. To explain this, and at the same time connect the condition with that found in other animals, I was induced to extend my inquiries upon this point into Mammalia generally. The results of this investigation I have incorporated with the present report.

Myology of the Anterior Limb.

Shoulder and upper arm.—Before entering upon a description of the muscles of the shoulder, it is necessary to refer to the condition of the clavicle. In the *Cuscus* and *Phascogale* this bone is well developed, and, stretching from the sternum to the scapula, has a distinct attachment to both. In the *Thylacinus*, on the other hand, the clavicle is exceedingly rudimentary. It is merely represented by a narrow curved rod of bone, about two inches in length, embedded in the substance of the cephalo-humeral muscle, and in no way attached to the acromion. To the sternum it is joined indirectly by an ill-defined fibrous band or raphe.

Trapezius.—This muscle has a similar origin in the three animals. It springs from the occipital crest, from the spinous processes of all the cervical vertebræ, and from the spines of the seven anterior dorsal vertebræ. From this extensive origin its fibres extend in the form of one unbroken muscular sheet, and converge towards the shoulder. Here the posterior and greater part of the muscle is inserted into the spine of the scapula (Pl. I. fig. 5, *tr.*), and the root of the acromion process, whilst the anterior portion sweeps over

[1] Transactions of the Geological Society, 1842, vol. vi., 2nd series on the *Phascolotherium*.

the head of the humerus, so as to clothe the humerus on its anterior and outer aspects, and is inserted differently in each animal. In the *Cuscus* a very few of these anterior fibres—those constituting the anterior free margin of the muscle—are attached to the clavicle. The remainder are continued downwards, and fuse with the acromial and clavicular portions of the deltoid. In the *Phascogale* the insertion of this part of the trapezius is precisely similar, with the exception that none of the fibres join the acromial deltoid—all enter the clavicular portion of that muscle. In the *Thylacine* the humeral division of the trapezius is more strongly marked than in either of the two preceding animals. In passing over the rudimentary clavicle, some of its deeper fibres mix with those of the other muscles attached to this bone, and it ends entirely in the clavicular deltoid (Pl. I. fig. 4, *tr.*).

According to Professor Macalister the humeral division of the trapezius in the Wombat is in no way attached to the clavicle, but, gliding over it, replaces the clavicular deltoid; in the Tasmanian Devil, on the other hand, no portion of the muscle reaches the humerus—all its fibres being inserted into the scapular spine, acromion process, and the outer fourth of the clavicle.[1] In the *Perameles* the anterior fibres of the trapezius are described by Professor Owen[2] as "being directly continued into the pectoralis major." Whilst the scapular or posterior portion of the trapezius therefore appears to be very constant in its insertion, the anterior or humeral part is subject to considerable variations.

Rhomboideus.—In none is this muscle divisible into its three constituent parts. In each of the three specimens it forms a continuous muscular layer, which arises for a varying extent from the occipital crest under cover of the trapezius and the cleido-occipital when this muscle exists, from all the cervical and from the two anterior dorsal spines. In the *Cuscus* and *Phascogale* the occipital origin is relatively wider than in the *Thylacine*. Those fibres which spring from the dorsal, and from the two or three cervical spines, are disposed in much coarser fasciculi than the fibres in the anterior part of the muscle, and they probably represent the rhomboideus proper. The entire muscle is inserted into the whole extent of the base of the scapula.

In the *Phascogale* the lower margin of the muscle, as it approaches the scapula, fuses with the upper border of the acromio-trachelien muscle, and in this manner it is inserted to a small extent into the root of the scapular spine.

Macalister[1] describes a more extensive origin of the rhomboideus in the Wombat. In this animal it extends back as far as the fourth or fifth dorsal spine. In the Tasmanian Devil, according to the same authority, it consists of two distinct portions, viz., a rhomboideus occipitalis and a rhomboideus proper composed of the amalgamated major and minor.

Acromio-trachelien (the omo-atlantic of Haughton and Macalister).—In the *Cuscus* and *Phascogale* this muscle is double; in the *Thylacine* it is single.

[1] Myology of the Wombat and Tasmanian Devil, Annals and Magazine of Natural History, vol. v.
[2] Comparative Anatomy and Physiology of Vertebrates.

In the *Cuscus* the acromio-trachelien consists of two distinct fleshy bands—a small superior band and a larger inferior band. These may appropriately be called the acromio-trachelien superior and acromio-trachelien inferior. The former arises by two slips from the transverse processes of the atlas and axis vertebræ, whilst the latter takes origin from the transverse process of the atlas alone. Narrow and rounded towards their origin they wind round the lower margin of the splenius, and then diverging from each other as they proceed backwards they expand into two thin muscular bands. Near the scapula they coalesce, and are inserted into the whole length of the scapular spine, and also into the posterior margin of the acromion process.

In the *Phascogale* the arrangement is very similar; still there are certain essential points of difference. Thus both fleshy bands arise from the atlas alone, they remain distinct throughout their entire extent, and, lastly, the acromio-trachelien superior, as it approaches the scapula, fuses by its upper margin with the rhomboideus.

In the *Thylacine* the single acromio-trachelien arises from the lower aspect of the transverse process of the atlas, and, expanding as it passes backwards, is inserted into the lower half of the scapular spine and into the posterior border of the acromion process (Pl. I. fig. 5, *a.t.*).

Cuvier and Laurillard (pl. clxxxviii.) figure a double acromio-trachelien in the *Macropus major*, the two parts of which are very distinct, and inserted at a considerable distance from each other.

Cleido-occipital.—This muscle is found in *Cuscus* and *Phascogale*, but it is absent in the *Thylacine*.

In the *Cuscus* (Pl. II. fig. 1, *c.o.*) it is a very narrow slip of muscle, and being closely applied to the upper margin of the cleido-mastoid, it is not at first apparent. Posteriorly it is attached to the sternal end of the clavicle, anteriorly it is inserted into the occipital ridge upon the same plane as the trapezius and sterno-mastoid.

In the *Phascogale* the cleido-occipital is a well-marked muscle, which is clearly mapped off from the cleido-mastoid throughout its whole length. Its attachments are the same as in the case of the *Cuscus*, but as it approaches the occiput it fuses with the anterior margin of the trapezius.

In the Wombat and Tasmanian Devil the cleido-occipital is absent; at least Macalister[1] makes no mention of it in either case. In Cuvier and Laurillard's plates it is figured in the *Didelphys cancrivora* (pl. clxxvi. fig. 1) and in the *Macropus minor* (pl. clxxxi. fig. 1), but not in the *Phalangista cavifrons* (pl. clxxix. fig. 1).

Cleido-mastoid.—In *Cuscus* and *Phascogale* this muscle arises from the sternal end of the clavicle, in close proximity to the origin of the cleido-occipital. As it proceeds forwards it sinks under cover of the sterno-mastoid to gain its insertion into the mastoid process.

[1] *Loc. cit.*, p. 3.

In the *Thylacine* the connections of the cleido-mastoid are very different. At the root of the neck it stands widely apart from its colleague the sterno-mastoid. Anteriorly it is attached to the mastoid process under cover of the sterno-mastoid. From this it is carried backwards towards the shoulder in the form of a narrow fleshy band. Reaching the rudimentary clavicle its fibres are partly inserted into the inner half of this bone, and partly continued into the clavicular deltoid (Pl. I. fig. 4, *c.m.*).

Latissimus dorsi.—This muscle has a shape very similar to that of the corresponding muscle in man. It arises from the spinous processes of all the dorsal vertebræ with the exception of the first and second, from the lumbar aponeurosis and by a single digitation from the last rib. From this wide origin it sweeps downwards and forwards so as to overlap the posterior angle of the scapula. In no case does it receive fasciculi from this bone. As it approaches the humerus it becomes much narrower, but, at the same time, what it loses in width it gains in thickness. In the *Cuscus* and *Phascogale* the insertion of the latissimus dorsi is identical; in the *Thylacine* it is somewhat different. In all it is more or less connected with that of the teres major.

In *Cuscus* (Pl. II. fig. 4, *l.d.*) and *Phascogale* the latissimus dorsi, as it approaches its insertion, divides into two parts. Of these the upper and smaller slip which corresponds with the anterior margin of the muscle passes behind the other part and joins the posterior margin of the teres major with which it is inserted. The posterior and main portion of the muscle gives off the dorsi-epitrochlear and then ends in a strong flat shining tendon. This proceeds outwards under cover of both heads of the biceps, and is inserted into the bottom of the broad shallow bicipital groove of the humerus. This attachment is separated by a wide interval from the insertion of the teres major, and abuts against that of the pectoralis major.

In the *Thylacine* the teres major and the latissimus dorsi have a common insertion into the humerus through the medium of a strong tendinous band, which arches backwards from the bottom of the bicipital groove. This band is twisted upon itself so that it presents a round, smooth, and cord-like posterior border. Into the lower half of this common tendon the teres major is inserted—a few of its fibres, however, obtaining a direct attachment to the humerus immediately below the lesser tuberosity; into the upper part of the tendon the latissimus dorsi is inserted.

Dorsi-epitrochlear.—This muscle is present in all, although relatively it is best developed in the *Phascogale*. It springs from the posterior margin of the latissimus dorsi a short distance from its insertion, and is carried downwards upon the inner aspect of the long head of the triceps. It is inserted in the *Cuscus* (Pl. II. fig. 4, *d.e.*) and *Phascogale* into the inner aspect of the tip of the olecranon process. In the *Thylacine* it joins the triceps near the elbow and is inserted with it.

Serratus magnus.—In the *Cuscus* (Pl. II. fig. 4, *s.m.*) only is there any indication of a division of this muscle into a cervical and a costal portion. In the *Phascogale* and

Thylacine it constitutes one unbroken muscular sheet. The cervical part is composed in all of five slips from the transverse processes of the five posterior cervical vertebræ. The costal origin differs in each case. In the *Cuscus* it is the most extensive, and consists of eight digitations from the eight anterior ribs ; in the *Phascogale* it is formed by seven digitations, and in the *Thylacine* by six digitations. In each animal it is inserted into the entire length of the base of the scapula.

Subclavius.—In the *Cuscus* (Pl. II. fig. 4, *s.c.*) and *Phascogale* the subclavius presents the ordinary attachments. In both it is very strongly developed, and arises by a pointed tendinous origin from the cartilage of the first rib. Expanding in a fan-shaped manner, it is inserted into the outer two-thirds of the upper sharp margin of the clavicle. In neither case does the muscle extend beyond the outer end of the clavicle towards the acromion process or supraspinatus fascia.

In the *Thylacine* (Pl. I. fig. 5, *s.c.*) the connections of the subclavius are very different. It is present in the form of a sterno-scapular band, which takes origin from the cartilage of the first rib, and then proceeds outwards upon the superficial aspect of the axillary vessels and nerves. Reaching the rudimentary clavicle, it sinks under cover of this bone and its attached muscles, and sweeps over the tuberosities of the humerus like a strap. It now changes its direction, and is carried upwards upon the supraspinatus, and is finally inserted into the fascia covering that muscle. It has no direct attachment to the scapular spine or to the outer end of the clavicle.

According to Macalister,[1] the subclavius in the Wombat is inserted directly into the outer sixth of the clavicle, into the upper border of the acromion process, and into the scapular spine. Professor Rolleston's description of the same muscle in this animal is somewhat different.[2] He states that it is inserted into the outer end of the clavicle, and by means of the fascia covering the supraspinatus into the whole length of the spine of the scapula. In any case, from its having a clavicular attachment, the Wombat exhibits an intermediate condition between the *Cuscus* and *Phascogale* on the one hand and the *Thylacine* on the other.

Cuvier and Laurillard figure (pl. clxxvi. fig. 1, *h.h'*) a subclavius muscle in *Didelphys cancrivora*, which appears to have similar attachments to those of the corresponding muscle in the Wombat. In the *Macropus major* (pl. cxcv. fig. 1, *h*), in the *Macropus minor* (pl. clxxxi. fig. 1, *h*), and in the *Phalangista cavifrons* (pl. clxxix. fig. 3, *h*) the same authorities figure the subclavius as it is found in the *Cuscus* and *Phascogale*. In the Opossum Professor Haughton[3] states that the subclavius is inserted into "the under surface of the outer third of the clavicle and the front of the acromion."

I fully agree with Professor Macalister in his remark, that "we can scarcely regard the sterno-scapular as anything but a variety of the subclavius."

[1] *Loc. cit.*, p. 3.

[2] On the Homologies of Certain Muscles connected with the Shoulder-Joint, Trans. Linn Soc., vol. xxvi. p. 626

[3] On the Muscles of Marsupials, Proc. Roy. Irish Academy, vol. ix. p. 485.

Pectoral muscles.—These muscles present a very complicated arrangement. In the *Cuscus* there are four distinct factors, viz. :—

(1) A large superficial fan-shaped muscle,
(2) An anterior deep band of muscular fibres, } pectoralis major.
(3) A posterior deep muscle, probably the pectoralis minor.
(4) The pectoralis quartus.

The first two may be regarded as being constituent parts of the pectoralis major. The large superficial fan-shaped portion (Pl. II. figs. 1 and 4, p^1.) arises from the whole length of the sternum and ensiform cartilage. From this it passes outwards, and is inserted into the outer lip of the bicipital groove, where it coalesces slightly with the clavicular deltoid. The deep portion (Pl. II. figs. 1 and 4, p^2.) takes origin from the anterior third of the sternum, and throughout is quite separated from the preceding muscle. Stretching outwards and slightly forwards as a thick fleshy band, it is inserted into the external tuberosity, and a small portion of the external bicipital ridge of the humerus. The pectoralis minor (Pl. II. figs. 1 and 4, p^3.) springs from the posterior two-thirds of the body of the sternum, and also from one or two of the costal cartilages. From this it proceeds outwards and forwards, and sinking under cover of the small deep portion of the pectoralis major, it is inserted into the inner margin of the great tuberosity of the humerus, into the capsule of the shoulder-joint, and through the medium of a strong aponeurotic membrane into the tendon of the supraspinatus and the coracoid process. Its origin from the costal arches and its indirect insertion into the coracoid process seem to indicate that this muscle is the pectoralis minor. The pectoralis quartus (so-called by Professor Macalister) (Pl. II. figs. 1 and 4, p^4.) arises behind the ensiform cartilage from the linea alba, and from the fascia over the rectus abdominis, and extends forwards and outwards under cover of the superficial part of the great pectoral to the upper part of the pectoral ridge into which it is inserted. The humeral portion of the panniculus carnosus (Pl. II. fig. 1, *p.c.*) fuses with it at its insertion.

In the *Phascogale* the pectoral muscles are identical with those of the *Cuscus* with two exceptions, viz., (1) there is no deep muscle corresponding with the deep portion of the pectoralis major; (2) the pectoralis quartus is more strongly developed, and is more in the form of a fleshy band.

In the *Thylacine* the pectoral muscles consist of a small superficial muscle, a large deep muscle, and a very rudimentary pectoralis quartus.

The superficial muscle is the representative of the pectoralis major. It arises from that part of the sternum which lies in front of the junction of the second costal cartilage.

The deep muscle, which is the representative of the pectoralis minor, springs from the whole of the sternum behind the preceding muscle, and also from some of the posterior costal cartilages.

The pectoralis major is inserted into the pectoral ridge of the humerus, whilst the pectoralis minor finds attachment at a higher level into the great tuberosity of the humerus, and also into the tendon of the supraspinatus. The two muscles therefore cross each other as they pass towards their insertions.

The pectoralis quartus is composed of two minute fleshy slips which arise from the linea alba, and end by fusing with the under surface of the pectoralis major.

A study of Cuvier and Laurillard's plates shows that the *Phalangista cavifrons* (pl. clxxix. fig. 2, $j, j^1, j^2 + j$), the *Macropus minor* (pl. clxxxi. fig. 1, $j, j^1, j^2, j +$), and the *Macropus major* (pls. cxciii. and cxciv.) agree in almost every respect with the *Cuscus* in the arrangement of the pectoral muscles. In the Wombat Professor Macalister[1] describes the same four pectoral muscles; in the Tasmanian Devil he states that the pectoralis major is not segmented (*i.e.*, there is no deep portion), and in this respect, therefore, it corresponds with the *Phascogale*. In both these animals, however, the great pectoral muscle receives fibres of origin from the clavicle.

There is a diversity of opinion regarding the character of the pectoralis quartus. Owen[2] looks upon it as "a dismemberment of the pectoralis major." Humphrey and Macalister[1] believe that it is in an "intermediate piece of the great superficial external muscular sheet between the pectoralis major and latissimus dorsi." Its close connection in many cases with the panniculus carnosus would almost seem to indicate that it is merely a portion of this muscle. In the *Cuscus*, indeed, it appeared to be simply the thickened lower margin of the panniculus, the connection between them was so intimate.

Scapular muscles.—In all the three specimens the supraspinatus is much more bulky than the infraspinatus. This is most marked in the *Phascogale* in which it is fully three times as large. In the *Thylacine* it is nearly twice as large (Pl. I. figs. 4 and 5, *s.s.*); in the *Cuscus* the disparity in size is not quite so great.

A teres minor, distinct from the infraspinatus, is present in the *Thylacine* (Pl. I. fig. 4, $t.m^2$.) and *Cuscus*. In both cases this muscle is supplied by a small twig from the circumflex nerve. It arises from a small portion of the axillary border of the scapula close to the glenoid cavity, and is inserted into the humerus upon its outer and posterior aspect immediately below the great tuberosity. In the *Phascogale* the teres minor is absent, and no twigs from the circumflex nerve could be traced to the portion of the infraspinatus which might be supposed to represent it.

The teres major is well developed in each of the three specimens. It has a very slight origin from the dorsum of the scapula at the posterior angle of the bone. Its main origin is from the axillary border of the scapula in its upper two-thirds. Here it is intimately connected with the posterior border of the subscapularis by means of an intermuscular septum, which gives fibres to both. In the *Cuscus* (Pl. II. fig. 4, *t.m.*) and *Phascogale* it receives a slip from the latissimus dorsi, and is then inserted into the inner

[1] *Loc. cit.*, p. 3. [2] Anatomy of Vertebrates, vol. iii. p. 12.

lip of the bicipital groove of the humerus. In *Thylacine* it is inserted in common with the latissimus dorsi through the medium of a fibrous arch (*vide* p. 5).

The subscapularis is well marked in all, and presents the usual attachments.

According to Meckel the infraspinatus is smaller than the supraspinatus in the Marsupialia generally. The accuracy of this observation is shown by Professor Macalister,[1] who gives the definite information that "the supraspinatus is larger in the Wombat, *Phalanger*, *Perameles*, *Sarcophilus*, and the Opossum; in the Giant Kangaroo they are about equal, while in Bennett's Kangaroo the infraspinatus is the larger."

Cuvier and Laurillard do not figure a teres minor in the *Phalangista cavifrons* (pl. clxxviii. fig. 1), but they represent a very strong teres minor in the Giant Kangaroo, (pls. clxxxvii. and clxxxviii.). This hardly agrees with Professor Macalister's description.[1] This author states that it is not separable from the infraspinatus in the *Macropus giganteus*, *Phalangista vulpina*, *Perameles lagotis*, and *Didelphys virginiana;* in the Wallaby, however, it is distinct, and in the Wombat and Tasmanian Devil it is represented by "a fascial band."

Deltoid.—In the *Cuscus* the scapular and clavicular portions (Pl. II. fig. 4, *c.d.*) of this muscle are distinct above, and separated from each other by a considerable interval. The scapular part is much the larger of the two; it arises from the acromion process, from the spine of the scapula in its entire length, and from the fascia covering the infraspinatus muscle. As the acromial part proceeds downwards, it is joined on its superficial surface by those fibres of the trapezius which in man are inserted into the acromion process. The clavicular portion of the muscle springs from the middle third of the clavicle, and it receives those fibres of the trapezius which in man are attached to the clavicle. Thus reinforced by trapezial fibres the two portions of the deltoid converge as they pass downwards towards a salient ridge jutting out from the antero-external aspect of the shaft of the humerus, at the junction of its upper and middle thirds. The scapular deltoid is inserted into the outer surface of this ridge, whilst the clavicular deltoid is fixed to its summit, where it is fused to a certain extent with the insertion of the pectoralis major.

In *Phascogale* the deltoid is broken up into three distinct factors—clavicular, acromial, and spinal—quite separate from each other except at their insertion. This triple constitution of the muscle is due to the acromial fibres passing down as a narrow band, apart from the fibres which take origin from the spine of the scapula. The humeral portion of the trapezius joins the clavicular deltoid alone, and has no connection whatever with the acromial part of the muscle. The insertion is the same as in *Cuscus;* the ridge in the shaft of the humerus, however, is not so strongly marked.

In *Thylacinus* (Pl. I. figs. 4 and 5) the deltoid is in two parts,—scapular (*s.d.*) and clavicular (*c.d.*),—and these are separate from each other both at their origin and at their insertion. The scapular deltoid is much the larger of the two, and it has a similar

[1] *Loc. cit.*, p. 3.

origin to the same muscle in *Cuscus*. It is inserted into the outer aspect of the shaft of the humerus about an inch below the great tuberosity, and at a higher level than the clavicular deltoid. It receives no fibres from the trapezius. The clavicular deltoid is composed of fibres derived from three distinct sources. In great part it is formed by fibres which come from the trapezius and the cleido-mastoid muscle, but it also obtains some which spring directly from the lower border of the rudimentary clavicle. Thus constituted it is inserted into a ridge upon the antero-external aspect of the shaft of the humerus about its middle, where it is partially fused with the insertion of the pectoralis major.

According to Macalister[1] the deltoid in the Wombat is double, whilst in the Tasmanian Devil it is triple as in the *Phascogale*. The same authority states that the muscle is "undivided" in the Giant Kangaroo, in *Macropus bennettii*, the *Phalanger*, and the Virginian Opossum. In the Koala[2] it is composed of two parts—clavicular and scapular. The above facts might lead us to question the general applicability of the assertion made by Owen in his great work upon the Comparative Anatomy of Vertebrates that "in claviculate Marsupials the deltoid . . . consists of three fasciculi."

Cephalo-humeral muscle.—We are now in a position to understand the constitution of the composite muscle to which this name is applied. In the *Cuscus* it consists of that portion of the trapezius which, in man, is inserted into the acromion and clavicle united with the acromial and clavicular parts of the deltoid. In the *Thylacine* and *Phascogale*, on the other hand, the acromial deltoid is not a constituent. In the former (Pl. I. fig. 4, *c.h.*) it is composed of the cleido-mastoid, the anterior fibres of the trapezius, and the clavicular deltoid, in the latter it is formed by the anterior fibres of the trapezius and the clavicular deltoid.

Coraco-brachialis.—Professor John Wood has taught us, in his well-known paper upon Muscular Variations,[3] to look upon the typical coraco-brachialis as being a muscle with a triple constitution. The animals in question afford a beautiful example of this. In each the coraco-brachialis brevis is present, and in *Thylacinus* it constitutes the sole representative of the muscle, which in this respect therefore resembles the carnivora. It springs from the coracoid processes, in common with the coracoid portion of the biceps, and spreading out in a fan-shaped manner, passes downwards over the insertion of the subscapularis to find attachment to the shaft of the humerus immediately above the insertion of the teres major. It is a short thick fleshy muscle.

In addition to the short muscle, the *Phascogale* possesses a coraco-brachialis medius—a very slender fasciculus which is inserted into the middle of the inner aspect of the shaft of the humerus, whilst in the *Cuscus* we find a coraco-brachialis longus (Pl. II. fig. 4, *c.b.l.*) inserted into the bridge of bone which walls in the supra-condyloid foramen of the humerus.

[1] *Loc. cit.*, p. 3. [2] Young, Muscular Anatomy of Koala, Journal of Anatomy and Physiology, vol. xvi.
[3] Journal of Anatomy and Physiology, vol. i.

In Cuvier and Laurillard's plates both the short and long slips are figured in the *Phalanger* (*Phalangista cavifrons*) (pl. clxxix. fig. 4, *q*); whilst in the Virginian Opossum (pl. clxxv. fig. 4, *q*) and the Giant Kangaroo the short muscle is alone represented. In the Wombat, *Sarcophilus*, and *Macropus ruficollis*, Professor Macalister[1] describes only the short variety of the muscle, but in the Koala Mr. Young[2] states that the three muscles are present, although the coraco-brachialis medius and coraco-brachialis longus are fused.

Biceps.—In the *Thylacine* the biceps springs by two tendons from the upper margin of the glenoid cavity and from the coracoid process. These after a short independent course unite to form a powerful flattened tendinous band from which the muscular fibres issue. At first the fleshy belly is undivided, but about the junction of the upper with the middle thirds of the upper arm it splits into a superficial and a deep portion (the coraco-radial and the gleno-ulnar muscles). The former is inserted into the radial tubercle, whilst the latter is fixed along with the brachialis anticus into the coronoid process of the ulna.

In the *Cuscus* (Pl. II. fig. 4, *b.*) and *Phascogale* the two portions of the biceps show similar attachments, but the fleshy bellies are distinct throughout, and there is merely a partial fusion of the tendons of origin. If the muscles be forcibly torn asunder in an upward direction it will then be seen that, whilst the gleno-ulnar arises from the upper margin of the glenoid cavity alone, the coraco-radial has a double origin, *i.e.*, both a coracoid and a glenoid origin; it therefore presents the same attachments as the entire muscle in man.

Brachialis anticus.—In the *Thylacinus* (Pl. I. figs. 4 and 5, *b.a.*) the brachialis anticus has a linear origin from the posterior aspect of the shaft of the humerus under cover of the outer head of the triceps, but separated from it by a well-marked external intermuscular septum. The muscle winds round the bone so as to clothe its outer surface and gain the anterior aspect of the limb at the elbow-joint; here it is inserted behind the gleno-ulnar into the coronoid process of the ulna.

In the *Cuscus* and *Phascogale* the brachialis anticus differs from that of the *Thylacine* in deriving fibres of origin from the outer aspect of the humeral shaft, and also in having a closer connection with the external intermuscular septum.

Triceps.—In Marsupials this muscle is usually very strongly developed, and the three animals under consideration offer in this respect no exception to the general rule. In *Thylacinus*, indeed, it seems to attain a maximum development. In all the three heads are easily separable.

In the *Thylacine* (Pl. I. figs. 4 and 5, tr^1. tr^2.) the scapular head has a very extensive and at the same time a somewhat peculiar origin. It springs from nearly the whole length of the axillary border of the scapula and by two distinct sets of fibres, viz., (1) a series which have a tendinous origin from the bone close to the glenoid cavity, and which pass down to constitute the long head of the triceps as it is usually observed. (2) A

[1] Annals and Magazine of Natural History, vol. v.

[2] Journal of Anatomy and Physiology, vol. xvi.

series of short fleshy fasciculi which arise from the scapular border above this, and which curve downwards and forwards in the form of a thin fleshy layer to blend with the fibres of the scapular head in its upper third. The external head takes origin from the posterior aspect of the humerus in its upper half, and is here blended with the brachialis anticus through the intervention of the external intermuscular septum. The inner head arises from the inner and posterior aspect of the humerus in all its length. It is pierced by the musculo-spiral nerve, which splits it into two distinct portions. The three heads of the triceps do not fuse until they reach the olecranon, into which the muscle has the usual insertion.

The *Cuscus* and *Phascogale* differ from the *Thylacine* in the following points:—(1) The long head does not spring from more than one-third of the scapular border, and all the fibres are derived from the one tendon of origin; (2) the inner head is weakly developed, and does not extend upwards upon the humerus beyond the insertion of the teres major; moreover, it is not pierced by the musculo-spiral nerve; (3) the three heads blend higher up the limb than in the case of the *Thylacine*. The triceps in *Cuscus* and *Phascogale* resemble very closely the triceps of man.

Macalister[1] states that in Marsupials "the lateral heads of the triceps are united into one large humeral muscle, inseparable from each other." I did not find this to be the case in the three animals in question.

Anconeus externus.—In the *Thylacine* the anconeus externus can hardly be said to exist. It is merely represented by a few of the lower fibres of the inner head of the triceps which are inserted upon the outer surface of the upper part of the olecranon. In the *Cuscus* (Pl. II. fig. 5, *a.e.*) it is largely developed, but inseparably united with the triceps. Springing from the back of the external condyle of the humerus, it is inserted into the outer surface of the olecranon and into the shaft of the ulna in its upper half. In the *Phascogale* the anconeus externus is almost identical with the same muscle in the *Cuscus*, but it is not so well marked, and does not extend so far down the shaft of the ulna. This muscle varies very greatly in its development in the different members of Marsupial group.

Anconeus internus (*Epitrochleo-anconeus*).—This little muscle is present in each of the three animals. It presents the usual attachments, viz., on the one hand, to the back of the internal condyle of the humerus, and on the other, to the inner side of the tip of the olecranon process. Its lower border is in opposition with a fibrous cord which bridges across the hollow between the condyle and the olecranon, and which gives origin to the fibres of flexor carpi ulnaris. In the *Cuscus* (Pl. II. fig. 4, *a.i.*) the anconeus internus is firmly united to the upper border of this cord, so that the two muscles are as it were merely separated by a fibrous raphe. In all cases the ulnar nerve passes under cover of the anconeus internus, and gives to it its nerve-supply.

[1] Annals and Magazine of Natural History, vol. v.

The anconeus internus is very generally present throughout the Marsupialia. Mr. Galton figures it in the Wombat;[1] Gruber in the *Dasyurus viverrinus*;[2] Cuvier and Laurillard in the Giant Kangaroo;[3] whilst it is described both by Macalister[4] and Young[5] in the Koala, and by the former author in the Tasmanian Devil.[6]

Forearm.

In the *Thylacinus* we find the following muscles upon the extensor aspect of the forearm :—

Superficial Muscles.

1. Supinator longus.
2. Extensor carpi radialis longior.
3. Extensor carpi radialis brevior.
4. Extensor communis digitorum.
5. Extensor digitorum secundus.
6. Extensor carpi ulnaris.

Deep Muscles.

1. Extensor ossis metacarpi pollicis.
2. Extensor secundi internodii pollicis.
3. Supinator brevis.

In the *Cuscus* the same muscles are found on the extensor aspect of the forearm as in *Thylacinus*.

In *Phascogale* the extensor carpi radialis longior and brevior are represented by a single muscle, whilst the extensor carpi ulnaris is split up into two factors. The deep muscles are the same as in *Thylacinus*.

Supinator longus.—In the *Thylacine* this muscle is very feebly developed. It consists of a narrow fleshy band (Pl. I. fig. 5, *s.l.*) which springs from the upper part of the external supracondyloid ridge of the humerus. The delicate thread-like tendon in which it ends passes under cover of the extensor ossis metacarpi pollicis, and is inserted in great part into the posterior annular ligament, but also slightly into the styloid process of the radius.

[1] Note on the Epitrochleo-anconeus or anconeus sextus (Gruber), Jour. of Anat. and Phys., vol. ix., pl. ii. fig. 3.

[2] Ueber den Musculus Epitrochleo-anconeus des Menschen und der Säugethiere, Mèm. de l'Acad. Imp. des Sci. de St. Pétersbourg, tom. x., No. 5, 7th series.

[3] Pl. clxv. fig. 1, *n*.

[4] On the Muscular Anatomy of the Koala, Annals and Magazine of Natural History, vol. x., 4th series, p. 130.

[5] On the Muscular Anatomy of Koala, Jour. Anat. and Phys., vol. xvi.

[6] Further Obervations on the Myology of *Sarcophilus ursinus*, Annals and Magazine of Natural History, vol. x., 4th series, p. 19.

In the *Cuscus* (Pl. II. fig. 5, *s.l.*) and *Phascogale* the supinator longus is a muscle of great size, relatively much larger than the same muscle in man. It springs from the upper two-thirds of the external supracondyloid ridge of the humerus. Its tendon proceeds in a groove upon the dorsal aspect of the lower end of the radius, under cover of the posterior annular ligament to the scaphoid bone, into the outer aspect of which it is inserted.

Macalister[1] mentions that the supinator longus is absent in the Tasmanian Devil; with this single exception it appears to be almost universally present in the Marsupialia, and in the case of the Koala it attains a very great magnitude.[2]

Radial extensors.—The fleshy bellies of the extensor carpi radialis longior and extensor carpi radialis brevior are completely amalgamated in the *Phascogale;* the tendons, however, are separate. This also was the case in the female *Thylacine*, but in the large male *Thylacine* (Pl. I. fig. 5, *c.l.* and *c.b.*) and in the *Cuscus* the two muscles were separate throughout their entire extent.

In the *Thylacine* and *Phascogale* the radial extensors arise from the external supracondyloid ridge of the humerus below the supinator longus, and they are respectively inserted into base of the second and third metacarpal bone on its dorsal aspect.

The extensor carpi radialis brevior in the *Cuscus* (Pl. II. fig. 5, *c.b.*) is a very large and powerful muscle, and its origin is somewhat complicated. It may be said to arise by three distinct heads—(1) from the upper part of the external condyle of the humerus (*c.b*^{1}.); (2) from the tendinous expansion on the surface of the supinator brevis (*c.b*^{2}.); (3) from the posterior border of the radius below the supinator brevis (*c.b*^{3}.). These three slips of origin unite to form the muscle, which is inserted as usual into the radial border of the shaft of the metacarpal bone of the medius a short distance beyond the base.

The extensor carpi radialis longior in the *Cuscus* (*c.l.*) presents the ordinary origin, from the lower third of the external supracondyloid ridge of the humerus, and it is inserted into the radial border of the shaft of the metacarpal bone of the index about its middle.

As a general rule, in the Marsupials the radial extensors are amalgamated, and even in those cases where they are separate they exhibit, as in the *Thylacine*, a tendency to fusion. Thus Young[2] states that in the three specimens of Koala which he examined one possessed a single radial extensor, whilst in the other two they were "separate and distinct." Again, Meckel,[2] in his work upon Comparative Anatomy, states that in the Opossum there are two radial extensors, whilst Macalister[3] describes only one. The peculiar triple origin of the extensor carpi radialis brevior which is noticed in the *Cuscus* has not been observed (so far as I am aware) in any other Marsupial.

Extensor communis digitorum.—In all three animals this is a comparatively small muscle. It springs from the outer aspect of the external condyle.

[1] Ann. and Mag. of Nat. Hist., vol. x., 4th series.
[2] Young, Jour. Anat. and Phys., vol. xvi.
[3] Annals and Magazine of Natural History, vol. v.

In the *Thylacine* (Pl. I. fig. 5, *c.d.*) the fleshy belly divides high in the forearm into three slips, from which three tendons issue. On the dorsum of the manus each tendon splits into two, and each part is inserted into the dorsal expansion on the first phalanx of the various digits; thus the first tendon (enumerating them from the radial side), by means of its two slips, goes to the index and medius, the second to the medius and annularis, and the third to the annularis and minimus. In this manner, therefore, the medius and annularis each receive two tendinous slips from the common extensor, whilst the index and minimus only obtain one.

In *Cuscus* (Pl. II. fig. 5, *c.d.*) and *Phascogale* the common extensor gives off four tendons. On the dorsum of the manus these communicate freely with each other, and go one to each of the four ulnar digits.

In the Koala Young[1] states that the common extensor gives a tendon to each of the five digits. This must be regarded as exceptional, because in the great majority of Marsupials its insertion is limited to the four inner digits.

Extensor digitorum secundus (Pls. I. and II. fig. 5, *r.l.*).—This muscle is undoubtedly the representative of the extensor mimimi digiti in man. It is essentially the same in each of the three animals. Arising from the external condyle of the humerus its tendon splits into two parts on the dorsum of the manus, and these go to be inserted into the dorsal expansions on the back of the annular and little digits.

Macalister[2] gives some interesting information regarding this muscle. In the Wombat, Opossum, and *Phalanger* it supplies tendons to the annular and little digits; in the Tasmanian Devil, Bennett's Kangaroo, and the Giant Kangaroo to the medius, annularis, and minimus.

Extensor carpi ulnaris.—In the large male *Thylacinus* (Pl. I. fig. 5, *c.u.* and *m.u.*), and in the *Phascogale* this muscle was split up into two distinct factors, which are inserted respectively into the unciform bone, and the ulnar face of the base of the fifth metacarpal. In the female *Thylacine* and in *Cuscus* (Pl. II. fig. 5, *c.u.*) there was a a single ulnar extensor muscle inserted into the metacarpal of the minimus.

Extensor ossis metacarpi pollicis.—In the *Cuscus* this muscle has a very extensive origin from the extensor surfaces of both bones of the forearm in their upper two-thirds, and from a corresponding portion of the interosseous membrane. It divides into two fleshy slips, which emerge in the interval between the common extensor and the short radial extensor, and end in tendons (Pl. II. fig. 5, *c.r.* and *m.r.*) which wind round the radial border of the forearm to be inserted into the trapezium, and into the base of the metacarpal bone of the pollex respectively.

In the *Thylacine* (Pl. I. fig. 5, *c.r.* and *m.r.*) the two portions of the muscle are separable throughout their whole extent. That which is inserted into the metacarpal bone arises from the middle third of the radius, whilst that portion which goes to the

[1] Jour. Anat. and Phys., vol. xvi. [2] Annals and Magazine of Natural History, vol. v.

trapezium springs from the lower half of the ulna, the adjacent part of the interosseous membrane, and very slightly from the radius.

In the *Phascogale* the muscle is very similar to the corresponding muscle in the *Cuscus*, but it has not so wide an origin.

It is very evident that this muscle in the Marsupials is a compound of the extensor ossis metacarpi, and the extensor primi internodii pollicis of man.

Extensor secundi internodii pollicis.—In the *Thylacine*, and *Phascogale* this muscle (which is undoubtedly the homologue of the muscle bearing the same name in man) sends tendons to three digits, viz., the pollex, index, and medius; in *Cuscus* it is split up into two distinct and separate muscles—one connected with the pollex alone, and the other with the medius.

In the *Thylacine* (Pl. I. fig. 5, *d.e.*) it springs from the radial side of the olecranon, and from the upper third of the posterior border of the ulna. In *Phascogale* the origin is similar, with this exception, that it has a more extensive attachment to the posterior border of the ulna. In both it is a thin band-like muscle, which proceeds downwards under cover of the ulnar extensors, and the extensor digitorum secundus to end in a single tendon. On the dorsum of the hand this tendon splits into three parts, which go to the three radial digits.

In the *Cuscus* (Pl. II. fig. 5, *e.p.*) the extensor secundi internodii pollicis arises by two distinct heads, viz., (1) from the radial surface of the olecranon and the posterior border of the shaft of the ulna in its upper third (*e.p*^{2}.); (2) from the radial border of the ulna in its middle third (*e.p*^{1}.). The anconeus externus extends downwards upon the ulna between these two heads (Pl. II. fig. 5, *a.e.*). Below the level of the anconeus the two slips of origin unite, and the tendon which issues from the fleshy belly goes to the second phalanx of the pollex.

The extensor medii (Pl. II. fig. 5, *e.m.*) in the *Cuscus* is a very delicate slip which springs from the middle third of the posterior border of the shaft of the ulna. It is inserted by a delicate tendon into the dorsal extensor expansion of the medius.

The extensor secundi internodii pollicis appears to be present in the majority of Marsupials. Thus Macalister describes it in the Wombat, Tasmanian Devil,[1] and Koala,[2] and Meckel speaks of it in the Opossum.[3]

Supinator brevis.—This muscle is feebly developed in all the three animals. In the *Cuscus*, in which it is best marked, it is inserted into rather less than the upper fifth of the anterior and inner surface of the shaft of the radius.

Posterior annular ligament.—This ligament forms five compartments on the back of the wrist in *Thylacinus* (Pl. I. fig. 5, *an.l.*) for the passage of the extensor tendons.

[1] Ann. and Mag. of Nat. Hist., vol. v., 4th series, p. 164.
[2] *Ibid.*, vol. x., 4th series, p. 131.
[3] Anat. Comp., vol. v. p. 329.

These are from the radial to the ulnar aspect of the limb—(1) on the radial border of the lower end of the radius for the tendons of the extensor ossis metacarpi pollicis; (2) on the dorsal aspect of the radius for the two tendons of the radial extensors; (3) in the nterval between the two bones of the forearm for the tendons of the extensor communis digitorum, and the tendon of the extensor secundi internodii pollicis; (4) on the dorsal aspect of the lower end of the ulna for the tendon of the extensor minimi digiti or extensor secundus digitorum; (5) on the ulnar aspect of the ulna for the tendon of the extensor carpi ulnaris.

In the *Cuscus* the posterior annular ligament presents seven compartments—(1) on the radial aspect of the wrist for the two tendons of the extensor ossis metacarpi pollicis; (2) on the dorsum of the radius for the supinator longus; (3) on the dorsum of the radius for the tendons of the two radial extensors; (4) on the dorsum of the radius for the extensor secundi internodii pollicis; (5) in the interval between the radius and ulna for the tendons of the common extensor and the extensor medii; (6) on the dorsum of the lower end of the ulna for the extensor minimi digiti; (7) between the styloid process and the lower end of the ulna for the extensor carpi ulnaris.

Turning now to the flexor aspect of the forearm, we find the following muscles:—

1. Pronator radii teres.
2. Flexor carpi radialis.
3. Palmaris longus.
4. Flexor carpi ulnaris.
5. Flexores digitorum.
6. Pronator quadratus.

Pronator radii teres.—The coronoid head of this muscle is absent in all. In *Cuscus* and *Phascogale* the muscle is very strongly developed; indeed, in the former it is inserted into the greater part of the radial margin of the shaft of the radius, viz., from the supinator brevis above to the root of the styloid process below. In *Thylacine* it is attached to the middle third of the external border of the radius.

Flexor carpi radialis.—This muscle is well marked in each of the three animals, and arises, in common with the great flexor muscle of the digits, from the internal condyle of the humerus. In *Cuscus* its tendon divides into two slips, and these are inserted one into the palmar aspect of the base of the second metacarpal, and the other into the palmar aspect of the base of the third metacarpal bone; in *Thylacine* it is inserted partly into the trapezium and partly into the base of the metacarpal bone of the pollex; and in *Phascogale* it is inserted into the trapezium alone.

The insertion of this muscle in Marsupials is somewhat variable. In the Wombat, *Phalanger*, Opossum, and Bandicoot it is inserted into the base of the second metacarpal;[1] into the metacarpal bone of the pollex[2] in Bennett's Kangaroo; and into the base of the middle metacarpal in the Koala.[3]

[1] Macalister, Ann. and Mag. of Nat. Hist., vol. v., 4th ser., p. 162.
[2] Haughton, Proc. Roy. Irish Acad., 1866, p. 479.
[3] Young, Jour. Anat. and Phys., vol. xvi. p. 230.

Palmaris longus.—In the *Thylacine* this muscle has very little direct attachment to the internal condyle of the humerus. It springs from the superficial aspect of the great flexor muscle of the digits, and ends in a powerful tendon which penetrates into the midst of the palmar pad. Here it breaks up into four strong slips which go to join the flexor sheathes of the four ulnar digits. In *Phascogale* the palmaris longus is arranged upon a similar plan, but in the palm it spreads out into a distinct palmar fascia.

In *Cuscus* there are three small muscular slips representing the palmaris longus, viz., (1) a very delicate fasciculus which springs directly from the internal condyle of the humerus; (2) a larger slip which arises in common with the great flexor of the digits; (3) and a deeper portion which issues from the superficial aspect of the flexor of the fingers. They all proceed to join the palmar fascia.

Flexor carpi ulnaris.—This muscle has a similar disposition in each of the three animals. It is a broad thin band which gradually tapers towards the point from which the tendon issues. As is customary in the majority of Marsupials it arises by two pointed processes—one from the internal condyle of the humerus, and the other from the olecranon process. Between these points it derives fibres from a strong fibrous arch which bridges across the interval between those bony prominences. In the *Thylacine* and *Phascogale* the lower border of the anconeus internus is in close apposition with this fibrous arch; in the *Cuscus* it is inseparably united with it. The ulnar nerve enters the forearm by passing downwards under cover of the anconeus internus and the fibrous arch in question. In all the three animals the flexor carpi ulnaris is inserted into the pisiform bone.

Flexores digitorum.—The flexor sublimis, the flexor profundus, and the flexor longus pollicis are in great part amalgamated in all the animals under consideration.

In *Cuscus* the great flexor mass arises in three parts, which in all probability represent the three factors which enter into its constitution. These may be termed (1) the radial, (2) the ulnar, and (3) the condylar.

The condylar portion is intermediate and superficial, and is probably the representative of the flexor sublimis. It arises from the internal condyle of the humerus. The radial portion springs from the anterior surface of the radius from the tubercle above to about the middle of the bone below. It lies under cover of the large pronatorradii teres, and represents the flexor longus pollicis. The ulnar subdivision takes origin from the ulnar surface of the olecranon under cover of the anconeus internus, and from the posterior border and ulnar surface of the shaft of the ulna in its upper half, under cover of the flexor carpi ulnaris. This portion apparently represents the flexor profundus.

The three subdivisions of the muscle thus derived unite to form a thick muscular mass, from the superficial aspect of which four minute and delicate fleshy slips issue. Each of these ends in a thread-like tendon, and they together constitute a flexor sublimis. The mass of the muscle now gives place to a rope-like tendon which is scooped out superficially

into a distinct longitudinal groove, and in this groove are lodged the four fleshy bellies and thread-like tendons of the flexor sublimis. This is the condition of affairs as low down as the lower border of the anterior annular ligament, but here the thick rope-like tendon divides into five parts, and these diverge—one going to each of the five digits. The minute tendons of the sublimis also separate and pass one to each of the four ulnar digits. On the fingers the tendons are arranged in the usual manner.

In the *Thylacine* and *Phascogale* the arrangement of the flexor muscle is very similar. In the former, however, it is to be noted that the condylar portion of the muscle is very much the largest of the three divisions, and also that the ulnar part springs from both bones of the forearm and from the interosseus membrane between them. Further, the four minute tendons of the sublimis have no fleshy bellies, but arise directly from the superficial surface of the rope-like tendon of the profundus.

The nerve supply of the great flexor muscle shows how thoroughly the fibres of the flexor sublimis and flexor profundus are commingled. Both the ulnar and median nerves send twigs to the condylar and ulnar portions of the muscle, whereas the radial portion derives its nerve-filaments from the median alone.

The lumbrical muscles are four in number in each of the three animals. They spring from the four ulnar tendons of the flexor profundus, and are inserted one into each of the four ulnar digits. In *Thylacinus* and *Phascogale* they are very minute and insignificant, but in *Cuscus* they are powerfully developed, and expand greatly at their insertions.

Pronator quadratus.—In *Thylacinus* this muscle lies over the lower fourth of the two bones of the forearm; in *Cuscus* and *Phascogale* it covers fully a third of the bones. Compared with other Marsupials, therefore, it may be considered to be poorly developed in these three animals.

Intrinsic Muscles of the Hand.

By the term intrinsic, as applied to the muscles of the hand, I mean those muscles which remain after the removal of the flexor and extensor tendons. It does not include the lumbricales.

In the *Thylacine*, *Cuscus*, and *Phascogale* the intrinsic muscles of the manus may be considered to consist of three groups, viz., (*a*) a palmar; (*b*) an intermediate; and (*c*) a dorsal, according to the plane which they occupy, as we dissect from the palmar to the dorsal aspect of the hand. But further, these three groups have each their own distinctive action upon the fingers with which they are connected, and thus this classification of them is founded, not only upon anatomical but also upon physiological grounds. The palmar group is composed of the adductors of the fingers. The dorsal group consists of the four dorsal interossei, and also of the abductor pollicis and abductor minimi digiti. The two

latter do not, strictly speaking, lie upon a plane posterior to the palmar and intermediate muscles. They are palmar in their orgin, but they cross the margins of the hand obliquely, and they are clearly dorsal in their insertion. Their palmar orgin is for the purpose of giving them a more powerful action upon their respective fingers. But it is their abducting action more than the position which they occupy in the hand which indicates their association with the dorsal interossei. The intermediate group of muscles is a series of paired muscles, which includes the flexor brevis pollicis and the flexor brevis minimi digiti. They are placed upon the palmar aspect of each metacarpal bone, and they act chiefly as flexors of the fingers at the metacarpo-phalangeal joints.

The manus of each of the three animals presents distinctive peculiarities in the arrangement of these muscles, and it is therefore necessary to study each in turn. As the *Phascogale* exhibits the simplest arrangement, we will begin with it.

Phascogale.

The hand of this animal is very minute. It measures only one inch in length and a quarter of an inch in breadth, and consequently the intrinsic muscles are extremely delicate.

Dorsal group.—The abductor pollicis is a very distinct muscle, which stretches over the radial margin of the palm. It arises from the annular ligament, and from the scaphoid and trapezium, and is inserted into the radial aspect of the base of the first phalanx of the thumb, on the same plane as the insertions of the dorsal interossei.

The abductor minimi digiti is about the same size as the preceding muscle. It arises from the unciform bone and the annular ligament, and is inserted into the ulnar side of the first phalanx of the little finger, on the same plane as the dorsal interossei.

The dorsal interossei are four in number, and occupy the intermetacarpal spaces. They have the same connections as the corresponding muscles in man. The dorsal group of muscles, therefore, abduct the fingers from a line drawn through the middle finger.

The palmar group.—This group is composed entirely of adductors. They are four in number, and are arranged so that they antagonise the abductors. They all arise close to each other, from the palmar aspect of the carpus, and from this point they radiate to their insertions. The first is inserted into the ulnar side of the first phalanx of the thumb, and is the representative of the adductor pollicis in man; the second goes to the ulnar side of the index; the third goes to the radial side of the ring finger, and the fourth is inserted into the radial side of the little finger.

In this way, then, the abductor minimi digiti, the abductor pollicis, and the first and fourth dorsal interossei, are antagonised by four special adductors, whilst the second and third dorsal interossei act alternately as adductors and abductors of the middle finger, as in the human hand.

Intermediate group.—The muscles which constitute this group are five in number, and are placed one over the palmar aspect of each metacarpal bone. That in relation to the metacarpal bone of the thumb is the flexor brevis pollicis, and that lying upon the metacarpal bone of the little finger is the flexor brevis minimi digiti. But further, each muscle consists of two slips, which in the case of the short flexors of the thumb and little finger, remain distinct and separate from each other throughout, whilst in the case of the other three they arise by a common tendon, and only separate the one from the other at a point corresponding to the middle of the metacarpal bones. The dorsal interossei are in no way connected with these muscles.

Flexor brevis minimi digiti.—This muscle is not so strongly marked as the short flexor of the thumb. Its ulnar head arises from the unciform bone, and from the annular ligament, whilst its radial portion takes origin from the carpus somewhat deeper. They extend downwards side by side, and are inserted one into each side of the base of the first phalanx of the little finger.

Flexor brevis pollicis.—The two slips of this muscle arise close together, from the second row of carpal bones, and are inserted one into each side of the base of the first phalanx of the thumb.

The three remaining muscles of this group (viz., those which correspond to the index, middle, and ring fingers) arise partly from the base of the metacarpal bone with which each is associated, and partly from the ligamentous bands on the palmar aspect of the carpus. Half-way down the metacarpus each muscle divides into two slips, and these are continued downwards so as to embrace the base of the first phalanx of the finger with which they are connected. Here the slips end in delicate tendons, which are inserted one into each side of the phalangeal base, partly into bone and partly into the extensor tendon.

These muscles lie in series with the short flexors of the thumb and little finger, and only differ from them in having each a single origin, and in being inserted in part into the dorsal extensor expansion. Moreover, their attachments indicate a correspondence of action. When the two slips of each muscle act in unison, they must flex the fingers at the metacarpo-phalangeal joints ; when they act separately and independently of each other, the action must be one of abduction or adduction, according to the slip employed, and this latter action must be performed most effectively by those muscles connected with the thumb and little finger, inasmuch as their slips are distinct from each other throughout, and not in any way hampered by the common origin of the others. The insertion of those muscles connected with the index, middle, and ring fingers into the extensor tendon, allows them to take a part in extending the fingers—a privilege which the flexor brevis pollicis and flexor brevis minimi digiti from their purely phalangeal insertions do not enjoy.

Thylacine (Pl. I. figs. 1–3).

Although the intrinsic muscles of the manus of this animal are arranged upon the same general plan as in the *Phascogale*, there are, nevertheless, certain important points of difference.

Dorsal group.—The abductor minimi digiti (figs. 1 and 3, *d*) and abductor pollicis (figs 1 and 3, *e*) are both present. The former is a very powerful muscle, and is attached, on the one hand, to the pisiform bone, and on the other to the ulnar face of the base of the first phalanx of the little finger. The abductor of the thumb is poorly developed, and with difficulty separated from the radial part of the flexor brevis pollicis. Its connections are similar to those of the corresponding muscle in the *Phascogale*.

The dorsal interossei are four in number when we view the dorsal aspect of the manus, but they are not all abductors in their action (fig. 2, d^1, d^2, d^3, d^4). The first and fourth alone have this action. The first is inserted by a single tendon upon the radial face of the first phalanx of the index, partly into bone and partly into the extensor tendon. The fourth is inserted similarly into the ulnar side of the ring finger. These muscles, therefore, abduct the index and ring fingers from the middle line of the hand. Very different is the action of the second and third dorsal interossei (d^2 and d^3). The former ends in a strong tendon which splits into two slips, and these are inserted one upon the radial face of the first phalanx of the middle finger, and the other upon the ulnar face of the first phalanx of the index. The third dorsal interosseous is inserted in precisely the same manner into the middle and ring fingers. The first and fourth dorsal interossei muscles abduct the ring and index from the middle line of the hand; the second and third approximate the three middle digits in the first instance, and then extend them.

Such are the connections of the dorsal interossei when viewed upon the dorsal aspect of the hand, but if we examine them upon their palmar surfaces after the removal of the palmar and intermediate muscles, we find an accessory slip in connection with each of the three ulnar muscles. These slips are apt to be confounded with the intermediate muscles, but careful dissection shows that they belong to the dorsal interossei. Two arise from the base of the middle metacarpal bone,—one from each side of it,—and they are inserted one into each side of the base of the first phalanx of the same finger. These are the abductors of the middle finger. The third slip arises from the base of the metacarpal bone of the ring finger (fig. 3, *h*), and is inserted into the ulnar side of the base of the corresponding phalanx. It is an accessory abductor of the ring finger.

Palmar group.—This group consists of three well-marked muscles lying upon the intermediate paired muscles, viz., (1) a large adductor of the little finger (fig. 1, *c*, and fig. 3, *c*, and c^1); (2) an abductor of the ring finger (figs. 1 and 3, *b*); (3) an adductor of the index (figs. 1 and 3, *a*).

These muscles have the same insertions as the corresponding muscles in *Phascogale*. They all arise from the front of the carpus—the adductors of the ring finger and index by a common tendon (fig. 3, *a.b*), and partly under cover of the origin of the adductor minimi digiti (fig. 3, *c*.) The adductor of the thumb is fused with the ulnar portion of the flexor brevis pollicis, but in one dissection it was readily separated as a distinct and exceedingly slender slip, having the same attachments as in the *Phascogale*.

The intermediate group of muscles (figs. 1 and 3, g^1 to g^6) corresponds in all respects with the same muscles in the *Phascogale*. At first sight they seem more complicated in their arrangement from the accessory slips of the dorsal interossei being associated with them.

Opponens pollicis.—This muscle is only present in the form of a few fibres, which pass from the conjoined abductor pollicis and radial part of the flexor brevis pollicis to the metacarpal bone.

The Palmaris brevis is very strongly marked. It cannot be considered as belonging to any one of the three groups of intrinsic muscles. It consists of two fleshy slips, both of which arise from the superficial aspect of the annular ligament. The smaller of these is inserted into the flexor sheath of the little finger, whilst the larger is attached to the ulnar side of the base of the first phalanx of the same finger.

Cuscus (Pl. II. figs. 2–3).

The abductors of the little finger (fig. 3, *d*) and thumb (fig. 3, *e*) are both present The former is more strongly developed than the latter, which is more or less completely fused with the radial head of the flexor brevis pollicis.

The four dorsal interossei differ somewhat in their relative sizes and mode of origin (fig. 2). The first, or abductor indicis (d^1) is very small, and consists of a single fleshy band, which arises from the palmar surface of the base of the metacarpal bone of the thumb, and is inserted into the radial side of the first phalanx of the index. The other three cannot be said to occupy the intermetacarpal spaces, inasmuch as they arise entirely from the dorsal surfaces of the metacarpal bones. The second (d^2) is the largest, and arises by two parts from the second and third metacarpal bones; the third (d^3) springs from the metacarpal bone of the ring finger; and the fourth (d^4) from the metacarpals of the ring and little fingers. They are inserted as in man, with the exception of the third, which, like the same muscle in the *Thylacine*, is inserted into the bases of the two fingers, between which it lies. Whilst the other dorsal interossei act as abductors of the fingers, the third approximates, and then extends the ring and middle fingers.

In the *Cuscus* there is a very beautiful arrangement by means of which the abducting power of these muscles is increased. The tendon of insertion of each muscle, with the exception of the abductor indicis, is fixed by a little transverse fibrous band to the head

of the metacarpal bone of the finger, which lies adjacent to that into which the muscle is inserted. By this the muscle is enabled to act at a greater advantage, because its tendon is prevented from clinging too closely to the base of the phalanx upon which it is acting. A similar arrangement can be made out in the *Thylacine*, but here the bands are weak in comparison with those found in the *Cuscus*.

The dorsal interrossei muscles of the *Cuscus* are provided with the same accessory slips in connection with their palmar surfaces as those we have already seen in the *Thylacine*. They are not nearly so well developed, however, and they are differently placed. The first is an adductor of the index; the second abducts the middle finger to the ulnar side of the hand; and the third abducts the ring finger. They are attached to the fingers with which they are associated in the same manner as in the *Thylacine*.

Palmar group (fig. 3).—The muscles which compose this group are the same as those in the two preceding animals, viz., (1) an adductor pollicis (*h*); (2) an adductor minimi digiti (*c*); (3) an adductor indicis (*a*); (4) and an adductor of the ring finger (*b*).

In man we see the adductor pollicis arising along the middle line of the hand from the middle metacarpal bone. It adopts this origin in order that it may obtain a more powerful action upon the thumb, and have a standpoint by means of which it may draw the thumb more completely across the palm of the hand. In the *Thylacine* and *Phascogale* there is also a tendency for the adductor muscles to seek the middle line of the hand for their origins. They arise close to each other, and then radiate towards their insertions. In the *Cuscus* all the adductors arise from the middle line, but in a different manner from the adductor pollicis in man. A median fibrous raphe extends downwards from the base of the metacarpal bone of the middle finger, and the adductors arise from each side of this. Thus the adductor pollicis and adductor mimimi digiti spring from the upper two-thirds of the raphe, the one opposite the other. They also arise, however, by a few fibres from the front of the carpus. The adductors of the index and ring fingers are very small, and take origin from the raphe below the preceding and also opposite each other. A few fibres forming a fleshy fasciculus (*a.b*), in front of the raphe, and in no way connected with it, pass round the base of the middle finger, and are attached, on the one hand, to the adductor tendon of the ring finger, and, on the other, to the adductor tendon of the index finger. It is an adductor of these fingers, but having no intermediate attachment, it must act upon both fingers simultaneously.

These muscles constitute with the raphe a thin stratum which hides from view the greater number of the intermediate muscles.

The *intermediate group* of muscles requires no special description. They agree in all essential points with the same muscles in the *Thylacine* and *Phascogale*. Of the two slips which compose the individual muscles it is somewhat curious to observe that whereas one is always inserted directly into the phalanx, the other has both an attachment to the phalanx and to the dorsal expansion of the extensor tendon. The flexor

brevis pollicis (fig. 3, g^1) and flexor minimi digiti (fig. 3, g^5) are exceptions to this rule, as both slips of each of these muscles are fixed directly to the bone.

The opponens minimi digiti is very distinct, but fused with the ulnar part of the short flexor. It is inserted into the lower half of the ulnar margin of the metacarpal bone of the little finger. This insertion is quite continuous with that of the short flexor of the same finger into the ulnar face of the first phalanx. There is no trace of an opponens pollicis.

The foregoing observations upon the intrinsic muscles of the hand are based upon four dissections of the manus of the *Thylacine*, two of the *Cuscus*, and one of the *Phascogale*. In addition I have also examined the hand of the *Vulpine phalanger*, the *Dasyurus viverrinus*, and the Australian wild Dog or Dingo, with the view of comparing the same muscles in them with those of the animals in which I was more specially interested.

The *Vulpine phalanger* in its hand muscles closely resembles the *Cuscus*, but the adductor or palmar group is feebly represented, and consequently the median raphe is not so well seen. The flexor brevis pollicis and the flexor brevis minimi digiti are apparently only represented by their radial and ulnar heads respectively, but these are strongly developed.

An opponens minimi digiti in all respects like that of the *Cuscus* is to be found, also a few fibres passing to the metacarpal bone of the thumb from the short flexor of that finger. The latter may represent an opponens pollicis.

The *Dasyurus*, on the other hand, agrees with the *Phascogale*. It has a powerful palmaris brevis similar to the same muscle in the *Thylacine*, and like the *Vulpine phalanger* it seems to be deficient in the adducting portions of the short flexors of the thumb and little fingers.

In the hand of the Dingo the metacarpal bones are compressed together so as to obliterate the intermetacarpal spaces, and in consequence of this the interossei muscles are situated in the palm. The clear definition between the three groups of muscles is therefore lost, more or less complete fusion of certain muscles takes place, and the arrangement is more difficult to interpret.

The abductors of the little finger and thumb are both present, but the latter is very rudimentary, like the digit upon which it acts. The four dorsal interossei lie upon the palmar surface of the metacarpal bones, and are fused to a certain extent with the representatives of the intermediate muscles in the Marsupials. They are poorly developed, and have the same insertions as the corresponding muscles in man.

The palmar muscles are three in number—(1) adductor pollicis, a very minute slip; (2) an adductor indicis; (3) an adductor minimi digiti.

The intermediate flexors are very similar to the same muscles in Marsupials, but the flexor brevis pollicis is suppressed, and the minute pollex is in this case flexed by the combined action of its abductor and adductor.

A few fibres of the adductor minimi digiti go to the radial margin of the metacarpal bone of this digit, and on this account it has been described as the opponens minimi digiti by veterinary anatomists.

But this description of the muscles of the hand of the Dingo does not agree with that given by Chauveau[1] of the same muscles in the domestic Dog. This author describes a flexor brevis pollicis, and speaks of an opponens pollicis and an opponens minimi digiti. The two latter are the representatives of the adductors of these fingers in man. Further, the muscle which he designates the adductor minimi digiti is in reality the abductor. Lastly, he looks upon the partially fused intermediary muscles and the dorsal interossei as composing a single series of muscles which he calls the metacarpal interossei.

The arrangement of the hand muscles in the Cat seems to be very similar to that in the Dog. Strauss-Durckheim, in his elaborate work upon the Anatomy of the Cat, gives a very careful account of these muscles. It is unfortunate that he has chosen for them a mode of nomenclature which renders his descriptions very obscure. He discards the term interossei, and calls all the intrinsic muscles of the hand adductors or abductors, according as they draw the digits towards or away from the middle line of the body. This leads to confusion, and it is only by a reference to his magnificent plates that his meaning can be clearly made out. He distinguishes three kinds of abductors and adductors, viz., short, middle, and long, according as they are inserted into the sesamoid bone, the base of the first phalanx or the second phalanx through the medium of the extensor tendon.

The above account of the intrinsic muscles of the manus was published in the form of an abstract in the Journal of Anatomy and Physiology (vol. xii.). Since then Dr. A. H. Young has greatly supplemented our knowledge of these muscles in the Marsupialia by describing them in five different species, viz., in the Opossum, the Wallaby, the Yellow-footed Rock Kangaroo, and the Wombat (Jour. Anat. and Phys., vol. xiv.), and still more recently in the Koala (Jour. Anat. and Phys., vol. xvi.). In all of these the arrangement of the intrinsic muscles is trilaminar.

The homologies of the intrinsic muscles will be fully discussed when we consider the corresponding muscles of the foot.

The Nerves of the Fore Limb of the *Thylacine* and *Cuscus*.

Swan, in his work upon the Comparative Anatomy of the Nervous System (p. 193), justly remarks that, as a general rule, the number of nerves entering into the composition of the brachial plexus in Mammalia is greatly influenced by the length of the neck. The number of vertebræ being, as a rule, the same, it follows that, when the neck is a lengthy one, the nerves are placed at greater intervals from each other, and in consequence of

[1] Comparative Anatomy.

this, fewer of the nerves take part in the formation of the plexus. This is very well exemplified in the case of the Dolphin and Ass respectively. In the former, where the cervical vertebræ are all compressed together so as to reduce the neck to a minimum, we find that the plexus is formed by the posterior five cervical nerves and the first two dorsal nerves.[1] In the Ass,[2] on the other hand, the last two cervical nerves and the first dorsal nerve are the only nerves which take part in the formation of the plexus. In the Horse and in Ruminants[3] the brachial nerves are represented by the last three cervical and the first and second dorsal nerves, and in man and animals with a neck of medium length the plexus is formed by the last four cervical nerves and the first and second dorsal nerves, as, for example, the Dog,[4] the Cat,[5] &c.

But this rule does not hold good in every case. In the Pig,[6] whose neck cannot be called long, the plexus is formed by the same nerves as in the Ass, and the Jaguar and the Fox[6] in this respect resemble the Horse.

In both the *Thylacine* (Pl. I. fig. 6) and *Cuscus* (Pl. II. fig. 6) the brachial plexus is formed, as in man, by the anterior primary divisions of the posterior four cervical nerves and of the first dorsal nerve. In the *Thylacine*, however, only a portion of the 5th cervical nerve enters the plexus. The 5th cervical nerve in this animal divides into two equal parts close to the intervertebral foramen, and diverging widely from each other, the posterior of these joins the plexus, whilst the anterior proceeds forwards under cover of the omo-hyoid muscle (*a*), and joins the 4th cervical nerve. It also gives cutaneous twigs to the neck and outer and dorsal aspects of the shoulder (*b* and *c*).

In the *Thylacine* the branches entering into the constitution of the brachial plexus join so as to present a more or less looped appearance, but the general plan of the plexus is very indefinite, irregular, and complicated (Pl. I. fig. 6).

The branches which proceed from it arise in the following manner:—(1) From the 5th and 6th cervical nerves the suprascapular (*s.*), the phrenic (*p.*), and the nerve to the subclavius (*s.c.*); (2) from the 6th and 7th the subscapular nerves (*s.s.*) and the external respiratory (*e.r.*); (3) from the 7th muscular branches to the panniculus carnosus (*p.c.*) and pectoral muscles (*p.m.*), the circumflex (*c.f.*), and the nerves corresponding to the musculo-cutaneous in man (*m.c.*); (4) from the 7th, 8th, and 1st dorsal the median (*m.*) and musculo-spiral (*m.s.*); (5) from the 8th and 1st dorsal the ulnar (*u.*) and internal cutaneous (*i.c.*).

In the *Cuscus* the brachial nerves have a more definite arrangement (Pl. II. fig. 6). They first unite so as to form four nervous loops, and from these two large trunks proceed—the one deriving fibres from the 5th, 6th, and 7th cervical nerves, and the other

[1] Spinal Nervous System of the Porpoise and Dolphin, Jour. Anat. and Phys., p. 217, 1876.

[2] Swan's Comparative Anatomy of the Nervous System. [3] Chauveau's Comparative Anatomy.

[4] Graduation Thesis on the Anatomy of the Dog, by J. H. Scott, M.D., unpublished, but to be consulted in the Library of the University of Edinburgh.

[5] Chauveau's Comparative Anatomy. [6] Swan's Comparative Anatomy of the Nervous System.

from the 8th cervical and 1st dorsal nerves—and embracing the axillary artery, they unite in the form of a flattened nervous band which lies upon the inner aspect of the axillary artery, between it and the vein. The principal branches of the plexus spring from this band.

The branches of the plexus may be conveniently classified under two heads :—(1) Those arising from the primary looped plexus ; (2) those which take origin from the flattened nervous band or plexus proper.

The first group includes—(1) the suprascapular (*s.*), phrenic (*p.*), and nerve to the subclavius (*s.c.*), all proceeding from the 5th and 6th nerves ; (2) the subscapulars (*s.s.*) coming—one from the 5th and 6th, and two from the 6th, 7th, and 8th ; (3) the external respiratory (*e.r.*) from the 6th and 7th ; (4) the circumflex (*c.*) from the 6th, 7th, and 8th ; (5) the musculo-spiral (*m.s.*) from the 7th, 8th, and 1st dorsal nerves.

The plexus proper gives orgin to the musculo-cutaneous (*m.c.*), median (*m.*), ulnar (*u.*), internal cutaneous (*i.c.*), and muscular branches to the panniculus carnosus (*p.c.*) and pectoral muscles (*p.m.*).

In the upper arm and forearm the distribution of the brachial nerves is very similar in the two animals, and, consequently, in this part of their course one description will suffice for both. In the manus, however, certain points of dissimilarity must be noted.

Circumflex (Pl. I. fig. 6, *c.f.* ; Pl. II. fig. 4, *c.n.*, and fig. 6, *c.*).—This is a large nerve, and has a more extensive cutaneous distribution than the corresponding nerve in man. It takes the usual course through the quadrilateral space, and round the neck of the humerus to reach the deep surface of the deltoid. Here it divides into two branches of equal size. Of these one immediately splits up into twigs for the supply of the deltoid and the teres minor. The other branch is cutaneous, and has a wide area of distribution. Emerging from under cover of the deltoid (Pl. I. fig. 5, *c.*) it becomes superficial upon the outer aspect of the upper arm, and not only supplies the skin in this locality, but is also continued downwards to the outer aspect of the forearm. This portion of the circumflex nerve is to be regarded as the substitute for the cutaneous part of the musculo-cutaneous in man, which is absent in these animals. It is interesting to note that in the Porpoise and Dolphin[1] a great part of the circumflex nerve is distributed as in *Thylacine* and *Cuscus* to the skin over the radial aspect of the arm and forearm.

Musculo-cutaneous (Pl. I. fig. 6, *m.c.* ; Pl. II. fig. 6, *m.c.*, and fig. 4, *m.c.n.* and *m.c.n*^{1}.). —This is a purely motor nerve, distributed only to muscles, and consequently the term "musculo-cutaneous" is a misnomer. It comes off in two parts. One of these passes outwards to supply the short coraco-brachialis, and the superficial biceps (Pl. II. fig. 4, *m.c.n*^{1}.), whilst the other passes obliquely downwards and outwards towards the elbow-joint, to supply the deep portion of the biceps and the brachialis anticus (Pl. II. fig. 4, *m.c.n.*). In the *Cuscus*, in which there is a well developed coraco-brachialis

[1] Cunningham, Spinal Nervous System of the Porpoise and Dolphin, Jour. Anat. and Phys., 1876.

longus, both nerves pass under cover of it to reach their destination, and the lower nerve supplies it. As a sensory nerve to the outer aspect of the fore limb, the musculo-cutaneous finds a substitute in the cutaneous division of the circumflex. It is by no means uncommon for the musculo-cutaneous to have a purely motor function. According to Swan,[1] this is the case in the Fox, and its place is here supplied by branches which spring from one of the long roots of the median, a little way above the elbow. In the Dog and the Cat it has the usual double distribution.[2]

Musculo-spiral (Pl. I. fig. 6, *m.s.*; Pl. II. fig. 4, *m.s.n.*, and fig. 6, *m.s.*).—This nerve does not end in front of the elbow by dividing into a radial and a posterior interosseous division. It is carried downwards to the extensor aspect of the forearm as one undivided trunk.

In its course it closely corresponds with the same nerve in other Mammals. Passing, in the first instance, downwards, it soon pierces the internal head of the triceps in the *Thylacine*, but in the *Cuscus* runs behind the humerus between the outer and inner heads of the muscle. It then comes forward through the external intermuscular septum, and continues its course to the elbow-joint upon the supra-condyloid ridge, and lies deeply in the interval between the supinator longus and the brachialis anticus. In the *Thylacine*, in which the supinator longus is poorly developed, it lies between the extensor carpi radialis longior and the brachialis anticus. At a lower level it lies directly upon the anterior ligament of the elbow-joint, and then diverging outwards and backwards it winds round the neck of the radius under cover of the supinator brevis in *Thylacinus*, but through its midst in the *Cuscus*, and thus gains the extensor aspect of the forearm. Here it is placed between the superficial and deep layers of extensor muscles, and ends by giving off numerous branches to the neighbouring muscles and one large cutaneous nerve (Pl. II. fig. 5, *m.s.n.*).

Branches.—On the inner aspect of the arm, before it pierces the inner head of the triceps, it supplies twigs to the middle and inner heads of the triceps, and also to the dorsi-epitrochlear muscle (Pl. II. fig. 4, *d.e.n.*), thus showing that this latter muscle must be associated with the triceps, and not with the latissimus dorsi from which it springs. Behind the humerus branches are given to the external head of the triceps; and on the outer aspect of the arm, before it passes under cover of the supinator brevis, it yields twigs to the supinator longus, extensor carpi radialis longior and brevior, and to the superficial aspect of the supinator brevis. On the dorsal aspect of the forearm (Pl. II. fig. 5, *m.s.n.*) it supplies all the extensor muscles, and the anconeus externus in the case of the *Cuscus*. The cutaneous branch is the direct continuation downwards of the nerve itself. It becomes superficial about the middle of the forearm by coming out between the extensor communis digitorum and the extensor secundus digitorum (*i.e.*, extensor

[1] Swan's Comparative Anatomy of the Nervous System.
[2] Chauveau's Comparative Anatomy.

minimi digiti), and giving a few twigs to the skin in this region, it is continued downwards in the *Cuscus* to the dorsum of the hand, where it ends in three branches which go one to the skin on each side of the middle finger, and the third to the radial side of the ring finger. In the *Thylacine* the nerve does not give any dorsal digital branches. It ends on the back of the wrist.

This cutaneous branch of the musculo-spiral is not the representative of the radial nerve in man. It is clearly the posterior interosseous nerve. A branch somewhat analogous to the radial is given off by the median.

Median (Pl. I. fig. 6, *m.*; Pl. II. fig. 4, *m.n.*, and fig. 6, *m.*).—This is the largest branch of the brachial plexus. In the upper arm it lies in close company with the humeral artery, and with it passes through the supra-condyloid foramen. In front of the elbow-joint it sinks deeply under cover of the pronator radii teres, and ends by dividing into (1) a superficial or radial branch, (2) the median proper. In the upper arm the main trunk gives off no branches; as it lies under cover of the pronator radii teres, however, it supplies twigs to each of the divisions of the flexor muscle, and also to the flexor carpi radialis. The twig to the ulnar portion of the flexor muscle—that part which represents the flexor profundus digitorum is very small.

Superficial or medio-radial nerve.—This nerve seems to take the place of the radial branch of the musculo-spiral which we have seen to be absent. It becomes superficial about the middle of the flexor aspect of the forearm, by appearing in the interval between the pronator teres and the flexor carpi radialis. It ends a short way above the wrist by dividing into a dorsal and a palmar branch (Pl. II. fig. 3, *m.r.n.*). In the forearm, before it comes to the surface, it gives off a few twigs to the pronator teres, and a long slender branch to the superficial aspect of the pronator quadratus. The latter accompanies the anterior interosseous artery, and is the representative of the interosseous branch of the median in man.

The palmar branch (Pl. II. fig. 3, *m.r.n.*) of the medio-radial nerve enters the palm by passing over the annular ligament in company with the superficial artery of the forearm, and after giving numerous twigs to the palmar pads, and a branch to the abductor pollicis and the radial and ulnar parts of the flexor brevis pollicis, it ends as the palmar digital nerve for the radial side of the thumb.

In the *Thylacine* the dorsal branch is much the larger of the two, and winding round the radial border of the forearm to the dorsal aspect of the wrist, it gives off a few twigs to the skin, and ends in dorsal digital branches for both sides of the thumb, index, and middle fingers, and the radial side of the ring finger. In the *Cuscus* it merely supplies digital branches to the pollex and index. The middle finger and the radial side of the ring finger in this case derive their nerve supply from the superficial branch of the musculo-spiral.

Median proper.—This nerve, accompanied by the main artery of the forearm, proceeds

downwards, and passing under cover of the flexor carpi radialis and the anterior annular ligament, enters the palm. It gives off no branches in the forearm. In the *Thylacine* the palmar branches are very numerous. Eight distinct twigs are given to the palmar pads, and then the nerve ends in digital branches which supply the palmar aspect of all the fingers with the exception of the radial side of the thumb and the ulnar side of the little finger. In the *Cuscus* the branches to the skin of the palm are not so plentiful, and digital twigs are only given to the index and middle fingers and to the ulnar side of the thumb and the radial side of the ring finger. In both animals the median nerve supplies all the lumbrical muscles. It also communicates freely with the palmar branches of the ulnar nerve on the one hand and medio-radial nerve on the other.

The ulnar nerve (Pl. I. fig. 6, *u.*; Pl. II. fig. 4, *u.n.*; Pl. II. fig. 3, *u.n.*) crosses the axillary vein, and running down the inner aspect of the limb to the interval between the olecranon and internal condyle of the humerus, it enters the forearm by passing under cover of the anconeus internus. In the forearm it lies between the ulnar flexor of the carpus and the ulnar part of the flexor muscle, and it ends at the junction of the middle and lower thirds of the forearm by dividing into a palmar (Pl. II. fig. 3, *u.n.*) and a dorsal branch. It supplies the anconeus internus, flexor carpi ulnaris, and a few small twigs proceed from it to the ulnar and condylar parts of the flexor muscle.

The palmar portion of the nerve, as it approaches the pisiform bone, divides into a superficial and a deep division. The former goes to the ulnar margin of the hand, supplies the abductor minimi digiti, and then proceeds onwards as the palmar digital branch for the ulnar side of the little finger. The deep division crosses the annular ligament superficially, under the shadow of the pisiform bone, and enters the palm. It at once sinks under cover of the ulnar head of the flexor brevis minimi digiti, and turning outwards is carried across the palm towards the radial margin of the hand between the plantar and intermediate strata of intrinsic muscles. It is expended in the supply of all the adductors, the dorsal interossei, and the short flexors, with the exception of the flexor brevis pollicis. In the *Cuscus* it supplies, in addition to these muscular twigs, the digital branch for the adjacent sides of the ring and little fingers. This nerve emerges from under cover of the adductor annularis (Pl. II. fig. 3, *d.n.*). In both it gives off branches to the skin of the palm.

The dorsal branch of the ulnar nerve winds round the ulnar margin of the forearm under cover of the tendon of the flexor carpi ulnaris, and it ends in digital branches for both sides of the little finger and the ulnar side of the ring finger.

The number of nerves which are given to the skin of the palm in the *Thylacine* is very surprising. Each of the three palmar nerves contributes to its supply—the median alone giving eight twigs. This seems to indicate that the palmar skin possesses an unusually high degree of sensibility.

Myology of the Hind Limb.

I regret that in this chapter I am only able to give an account of the myology of the hind limb in the *Thylacine* and *Cuscus*. The pelvis and posterior limbs of the *Phascogale* were so shattered with shot that it was impossible to conduct a proper examination of their anatomy.

Gluteal Region.

Gluteus maximus (ecto-gluteus) (Pl. III. fig. 1, *ec.g*^{1}., *ec.g*^{2}., *ec.g*^{3}.; and Pl. IV. fig. 5, *ec.g*^{1}. and *ec.g*^{2}.).—In the *Cuscus* the gluteus maximus is represented by three muscles all occupying the same plane, and placed superficial to the other structures of the gluteal region. These three muscles arise in a continuous line from the anterior superior spine of the ilium in front to the fourth caudal vertebra behind. The two posterior muscles are only partially separated from each other, and they together represent the agitator caudæ. The anterior muscle is the combined gluteus maximus and tensor fasciæ femoris.

The agitator caudæ (Pl. III. fig. 1, *ec.g*^{2}., *ec.g*^{3}.) is a large, powerful muscle. Its anterior and smaller portion arises from the fascia over the hinder part of the sacrum and from the first caudal vertebra; the wider posterior portion springs from the fascia over the second caudal vertebra and from the transverse processes of the third, fourth, and fifth caudal vertebræ. Both portions of the muscle are inserted into the posterior aspect of the femur in a continuous line from the root of the great trochanter above to within an inch of the external condyle below (*ec.g*^{2}. × and *ec.g*^{3}. ×).

The combined gluteus maximus and tensor fasciæ femoris (Pl. III. fig. 1, *ec.g*^{1}.) is a thin layer of muscular fibres which arises from the fascia over the last lumbar vertebra and the sacrum, from the fascia over the gluteus medius (meso-gluteus) muscle and also from a tendinous cord which passes horizontally backwards from the anterior superior spine of the ilium. This fibrous cord is fully an inch and a half long, and gives origin by its superior border to the three gluteal muscles, whilst by its inferior margin it gives attachment to the sartorius and the obliquus internus. At first sight it has the appearance of being the representative of Poupart's ligament, but it cannot in any respect be considered the homologue of this structure, seeing that the aponeurosis of the external oblique is in no way connected with it. The gluteus maximus is inserted into the outer aspect of the root of the great trochanter, and also slightly into the posterior aspect of the shaft of the bone below this. The posterior margin of the muscle is free, and quite distinct from the agitator caudæ; in front, however, it winds round the anterior border of the meso-gluteus (Pl. III. fig. 1, *ec.g*^{1}. ×), and becomes inseparably connected with the gluteus minimus (endo-gluteus). In this manner, therefore, the superficial and deep gluteal muscles enclose the meso-gluteus on all sides except posteriorly. That the anterior fibres of the muscle just described represent the tensor

fasciæ femoris is shown by the fact that a twig from the superior gluteal nerve can be traced into their midst (Pl. III. fig. 1, *s.g.n.*).

In almost all the muscles of the gluteal region of *Thylacinus* there is a marked tendency to segmentation. The gluteus maximus (Pl. IV. fig. 5, *ec.g*^{1}. and *ec.g*^{2}.) differs materially from the corresponding muscle in *Cuscus*. It consists of two portions which lie one behind the other, and each is segmented into a superficial and deep part. The posterior division represents the agitator caudæ. The anterior part or gluteus maximus proper lies altogether behind the gluteus medius (meso-gluteus). Its superficial segment springs from the fascia on the dorsal aspect of the sacrum. It is a thin fleshy stratum which is inserted into the back part of the great trochanter (*ec.g*^{1*}.). The deep segment, narrower but more fleshy than the superficial part, takes origin from the side of the sacrum in its posterior half, and also from the fascia on the dorsum of the sacrum; it emerges from under cover of the superficial segment near the trochanter major, and is inserted into the posterior aspect of the femur immediately below its fellow (*ec.g*^{1*}.).

The agitator caudæ (*ec.g*^{2}.) by its superficial segment springs from the fascia over the anterior three caudal vertebræ, and by its deep segment from the transverse process of the second caudal vertebra. The latter is a very narrow band, and after a short independent course they unite to be inserted into the posterior aspect of the femur below the deep segment of the gluteus maximus (*ec.g*^{2*}.).

The four muscular factors which in *Thylacinus* thus represent the gluteus maximus in man are supplied by a special nerve from the sacral plexus. In the *Thylacine* there is apparently no trace of the tensor fasciæ femoris.

Gluteus medius (meso-gluteus).—In both animals this muscle is powerfully developed and quite distinct from the gluteus minimus. In *Cuscus* (Pl. III. fig. 1, *m.g.*) it is a thick fleshy muscle which arises from the short iliac crest, from the dorsum ilii, from the fascia covering it, and from the tendinous cord already referred to as giving common origin to the three gluteal muscles. It is inserted into the summit and outer aspect of the great trochanter of the femur (*m.g.* +).

The gluteus medius in the *Thylacine* (Pl. IV. fig. 5, *m.g.*) is segmented into a superficial and deep portion. The former is inserted into the outer aspect of the great trochanter (*m.g**.), whilst the latter is attached to its summit. The deep segment is not so broad or fleshy as the superficial part, and is received into a deep hollow in its under surface, so that at first sight it appears as if the one segment were enclosed within the substance of the other.

In the Koala[1] the gluteus medius is also frequently bilaminar.

Gluteus minimus.—This muscle is quite distinct in both animals from the gluteus

[1] Young, Muscular Anatomy of the Koala, Jour. Anat. and Phys., vol. xvi. p. 234.

medius. According to Macalister[1] the two muscles are hardly separable in the Wombat and *Sarcophilus*. As a general rule, however, in Marsupialia they are quite distinct. It is a wide thin muscle which arises in both instances from the dorsum ilii and from the ischium as far back as the gemelli. It thus almost completely covers the superior aspect of the hip-joint (Pl. III. fig. 1, *en.g.*, and Pl. IV. fig. 5, *en.g.*). In the *Cuscus* its anterior border is blended with the corresponding margin of the gluteus maximus. It narrows towards its insertion, and all its fibres converge to be attached to the anterior border of the great trochanter of the femur.

Gluteus quartus.—In *Thylacinus* this muscle is well developed (Pl. IV. fig. 2, *g.q.*). Somewhat triangular in shape it springs by a pointed origin from the margin of the acetabulum close to the reflected tendon of the rectus femoris (*r.f*[2].). Expanding as it proceeds downwards over the anterior aspect of the capsule of the hip-joint, it enters the interval between the vastus externus and vastus internus, and is inserted into the front of the shaft of the femur immediately below the neck. In the *Cuscus* the gluteus quartus is also present, but it is very feebly marked, and consists of a single delicate muscular slip.

In neither case was I able to make out with precision the nerve supply. Until this is done the homologies of this minute muscle cannot be considered as established. Although usually grouped with the gluteal muscles it seems to have a closer relationship to the extensor muscles. It is generally present in Marsupiala. Macalister[1] describes it in the Wombat, *Sarcophilus*, Giant Kangaroo, Bennett's Kangaroo, the *Phalanger*, and the Opossum. Neither Macalister[2] nor Young[3] mention it as existing in the Koala.

Pyriformis.—This is a strongly-marked triangular muscle, which lies upon the posterior part of the gluteus minimus behind the gluteus medius (Pl. III. fig. 1, *p.*; and Pl. IV. fig. 5, *p.*). It springs from the lower surface and outer margin of the sacrum, and is inserted by a rounded tendon into the posterior part of the summit of the great trochanter. It is identical in both animals. Macalister[1] states that it is "undistinguishable from the gluteus medius in the *Phalangista*."

Ischio-femoral (Pl. III. fig. 1, *i.f.*, and Pl. IV. fig. 5, *i.f.*).—This muscle is commonly described as the quadratus femoris, but it lies on a different plane, viz., superficial to the gemelli, the true quadratus and the adductor magnus. It seems to me therefore that it must be regarded as a separate muscle, the precise nature of which is doubtful. It is an exceedingly thin fleshy band which arises from the great sacro-sciatic ligament, and is inserted into the posterior aspect of the femur below the great trochanter between the insertions of the ecto-gluteus and the adductor magnus. It is more strongly marked in the *Thylacine* than in the *Cuscus*, and its deep surface is partially fused with the subjacent adductor magnus.

[1] Myology of the Wombat and Tasmanian Devil, Ann. and Mag. Nat. Hist., vol. v., 4th series, p. 167.
[2] Muscular Anatomy of Koala, Ann. and Mag. Nat. Hist., vol. x., 4th series.
[3] Young, Anatomy of Koala, Jour. of Anat. and Phys., vol. xvi.

Obturator internus and gemelli.—The obturator internus is present in both the *Thylacine* and *Cuscus*. It is strongly developed in the latter, but comparatively feeble in the former. In both, its tendon plays in the small sciatic notch, but the encrusting cartilage of this is not raised into ridges, and thus the tendon does not display the longitudinal furrows which are so characteristic of the same muscle in man. It is inserted along with the obturator externus into the bottom of a deep recess which exists between the great trochanter and the neck of the femur.

The gemelli are enormously developed. In the *Cuscus* they are inseparable except at their origin. The superior (or anterior) gemellus springs from the ischium in front of the small sciatic notch, whilst the inferior (posterior) gemellus arises from the tuber ischii. The tendon of the obturator internus lies in a groove in their substance, and they are inserted into this tendon. The nerve to the quadratus femoris passes downwards through the substance of the gemelli.

In the *Thylacine* the gemelli are still more strongly marked, and each consists of a superficial and deep segment. These fuse as they pass towards their insertion, which is partly into the tendon of the obturator internus, but chiefly into the recess between the great trochanter and the neck of the femur. The nerve to the quadratus femoris passes downwards between the segments of the gemellus superior, but under cover of both parts of the gemellus inferior.

Obturator externus.—This is an exceedingly powerful fan-shaped muscle, which presents the usual origin in both animals. It is inserted by a broad band-like tendon into the trochanteric fossa below the tendon of the obturator internus.

Quadratus femoris.—This is a thick fleshy muscle, which lies upon the same plane as the adductor magnus, and is quite separate from it in the *Cuscus*, although in *Thylacinus* it is partially fused with its upper border. It arises from the tuber ischii, and is inserted into the lower part of the posterior border of the great trochanter, and also into the posterior aspect of the shaft of the femur below this for nearly an inch. As compared with the corresponding muscle in man, it is relatively larger, and its fibres are more oblique and coarser.

Hamstring Muscles.

In both *Thylacinus* and *Cuscus* we find the following hamstring muscles:—(1) The biceps with its accessory parts, (2) the semi-tendinosus, and (3) the semi-membranosus.

Biceps.—This muscle presents the simplest arrangement in the *Cuscus*. It is composed of two distinct parts, viz., an ischial part or biceps proper and a caudal part.

The biceps proper (Pl. III. fig. 1, *b.*) arises by a narrow and pointed origin from the ischial tuberosity in common with the semi-tendinosus. As it is followed downwards it rapidly expands so as to assume a marked triangular form, and it is inserted into the

fascia on the outer aspect of the leg from the external condyle of the femur in front to the external maleolus behind. It has no femoral head of origin, so that the name biceps is in this respect inappropriate.

The caudal portion (Pl. III. fig. 1, *c.t.*) of the muscle has not been noticed in any Marsupial so far as I am aware.[1] It is a long ribbon-shaped muscle, which arises in the gluteal region from the transverse processes of the first and second caudal vertebræ in the same plane as the gluteus medius, and under cover of the agitator caudæ. From this origin it proceeds downwards in the interval between the ischial tuberosity, and the great trochanter superficial to the biceps proper. The bicipiti accessorius of Haughton lies under cover of the biceps. Reaching a point opposite the posterior aspect of the knee-joint, it gives a small muscular slip to the semi-tendinosus (Pl. III. fig. 1, *s.t.*, and fig. 2, *s.*), and splits into two divisions, which diverge from each other so as to embrace the posterior aspect of the leg. The fibular division fuses with the posterior margin of the biceps proper, and is inserted with it into the fascia on the outer aspect of the leg; the tibial portion, which is the longer of the two, ends in an aponeurotic expansion which is inserted (Pl. III. fig. 2, *c.t.*) into the inner subcutaneous surface of the tibia about its middle, at a lower level than the insertion of the semi-tendinosus (Pl. III. 2, *s.t.*), and slightly overlapped by the gracilis (Pl. III. fig. 2, *g.*).

In *Thylacinus* the biceps muscle is very complicated. It consists essentially of three portions—(1) a biceps proper, (2) a superficial caudal portion, and (3) a deep caudal part. These three subdivisions are brought into close association with each other by numerous fleshy slips which pass from the one to the other.

The biceps proper (Pl. IV. fig. 5, *b.*) is more massive than in *Cuscus*, and not nearly so expanded at its insertion; indeed, it is merely inserted into the fascia over the outer aspect of the knee and upper third of the leg.

The superficial caudal division (Pl. IV. figs. 1 and 5, b^2.) of the muscle is the representative of the caudal part of the biceps in the *Cuscus*. It arises from the transverse processes of the second and third caudal vertebræ, and passing downwards upon the origin of the biceps proper it gives a slip to the semi-tendinosus (*s.t.*), and then divides into a tibial and fibular part. The tibial portion (Pl. IV. fig. 1, b^3.) is the larger of the two, and being reinforced by a slip from the semi-tendinosus it proceeds downwards along with this muscle to the inner aspect of the leg, where it is inserted into the tibia about the middle of its inner subcutaneous surface. The fibular part (Pl. IV. fig. 5, b^2.) is reinforced by a long slender slip from the biceps proper, and is inserted into the fascia on the outer aspect of the leg, behind and in conjunction with the biceps proper.

The deep caudal portion (Pl. IV. fig. 5, b^1.) of the biceps muscle represents the bicipiti accessorius of Haughton. It is a long narrow slip which springs from the transverse

[1] It appears to be figured by Cuvier and Laurillard in the Kangaroo Rat and in the Opossum (pl. clxxx. r^1 and pl. clxxiv. r^2).

process of the first caudal vertebra—on the same plane with the superficial muscle, and under cover of the agitator caudæ. It passes downwards under cover of the biceps proper, and appearing at its posterior border is inserted into the fascia on the fibular aspect of the leg.

These caudal divisions of the biceps muscle are undoubtedly present for the purpose of associating the movements of the heavy tail with those of the hind limb.

The bicepiti accessorius appears to be only occasionally present. According to Macalister[1] it is found in *Sarcophilus*, but "is absent in the Wombat, Giant Kangaroo, Bennett's Kangaroo, *Phalanger*, and Opossum. Young,[1] however, asserts its presence in the Opossum, but states that it is absent in the Koala.

Semi-tendinosus (Pl. III. fig. 1, *s.t.*, and fig. 2, *s.t.*; Pl. IV. fig. 5, *s.t.*, and fig. 1, *s.t.*).—In both animals this muscle has the usual origin from the tuber ischii, and in both its origin is partially blended with that of the biceps proper. Its connections with the supercaudal portion of the biceps have already been noticed. In *Cuscus* it is inserted into the inner aspect of the tibia about its middle, and completely under cover of the gracilis (Pl. III. fig. 2, *s.t.*); in *Thylacine* it is inserted very much higher up, and at a lower level than the gracilis (Pl. IV. fig. 1, *s.t.*).

In *Thylacine* the muscle is traversed by a faint tendinous intersection, but no such appearance was visible in *Cuscus*. It is a rare occurrence to find such in the semitendinosus of a Marsupial.

Semi-membranosus.—Little need be said about this muscle. It has the usual origin, and it ends in a round tendon which passes under cover of the strong cord-like internal lateral ligament (Pl. III. fig. 1, *i.l.l.*) of the knee to be inserted into the side of the anterior tuberosity of the tibia. It acts, therefore, as a rotator of the leg upon the thigh, as well as a powerful flexor (Pl. III. fig. 2, *s.m.*, and Pl. IV. fig. 1, *s.m.*).

Muscles on the Anterior and Inner Aspects of the Thigh.

Sartorius.—In both cases this muscle arises from the anterior superior spine of the ilium. In *Cuscus*, owing to the flexed condition of the thigh, it is at first closely applied to the lower part of the abdominal wall. Expanding into an exceedingly thin sheet of muscular fibres, it is inserted into the tendinous expansion of the quadriceps extensor muscle on the front of the knee, and also into the fascia upon the inner aspect of the joint (Pl. III. fig. 1, *s.*). In *Thylacinus* it is a thick prismatic muscle, and is inserted entirely in front of the knee-joint into the quadriceps expansion.

These animals therefore prove no exception to the rule that in Marsupialia generally the sartorius acts chiefly as an extensor of the leg upon the thigh.

[1] Myology of the Wombat and Tasmanian Devil, Ann. and Mag. Nat. Hist., vol. v., 4th ser.
[2] Muscular Anatomy of Koala, Jour. of Anat. and Phys., vol. xvi. p. 235.

Quadriceps extensor.—In both *Thylacine* and *Cuscus* the rectus femoris (Pl. III. fig. 1, *r.f.*, and Pl. IV. fig. 5, *r.f.*) has a double origin. In the latter, the reflected head is much the larger of the two; the other head, although quite distinct, is a very slender tendon indeed. In the *Thylacine*, the reflected head is also strongly marked (Pl. IV. fig. 2, $r.f^2$.), but the other head is developed to an enormous extent, and strongly reminds one of the appearance presented by the long head of the triceps in the fore limb of the same animal (Pl. I. fig. 5, $t.r^1$.). It takes origin by a thin aponeurosis which is attached to the entire length of the lower border of the ilium from the reflected tendon behind to the anterior superior spine of the ilium in front. This aponeurosis gives place to a thick fleshy triangular portion of muscle, which joins the belly of the reflected head to form the mass of the rectus femoris.

Young[1] describes the rectus femoris as possessing two heads in the Koala, and Professor Owen[2] mentions a similar condition of the muscle in *Perameles lagotis*. Macalister,[3] however, states that in *Phalangista vulpina*, the Opossum, the Wombat, the Tasmanian Devil, the Giant Kangaroo and Bennett's Kangaroo the rectus femoris arises by a single head from the anterior inferior spine of the ilium.

Of the other factors of the quadriceps the vastus externus is the most strongly developed. It alone also is partially separable from the others. The vastus internus and the crureus are intimately blended, the one with the other. In the *Cuscus* there was a very distinct subcrureus; in the *Thylacine*, however, there was no trace of such a muscle.

In neither animal is there an osseous patella, but the different portions of the quadriceps, together with the sartorius, unite to form an exceedingly dense and thick tendinous expansion in front of the knee-joint. This is so excessively tough and resistent to the knife that it almost resembles fibro-cartilage in its consistence. In the Wombat[3] it apparently attains a cartilaginous structure.

Psoas and *Iliacus.*—In the great majority of the Marsupial group the psoas parvus attains a greater size than the psoas magnus. In the two animals under consideration it is much the larger, and takes origin from the bodies of six vertebræ (viz., the last dorsal and the anterior five lumbar). It ends in a long round tendon, which is inserted into the anterior border of the pubic bone, close to the os marsupium, and immediately in front of the acetabulum.

In the *Cuscus* the psoas magnus arises from the bodies of the last two lumbar vertebræ, and also from the upper part of the sacrum. It blends with the iliacus.

In the *Thylacine* the psoas magnus consists of two distinct portions. The anterior part is the larger of the two; in front it is blended with the psoas parvus, whilst behind it springs from the bodies, and transverse processes of the last two lumbar vertebræ. It ends by joining the iliacus. The posterior portion springs from the last lumbar vertebra,

[1] Muscular Anatomy of the Koala, Jour. Anat. and Phys., vol. xvi. [2] Todd's Cyclop., vol. iii. p. 290.
[3] Muscular Anatomy of Tasmanian Devil and Wombat, Ann. and Mag. Nat. Hist., vol. v., 4th ser.

and the two first pieces of the sacrum, and it is inserted into the upper part of the small trochanter independently of the iliacus.

The iliacus springs from the lower border and iliac fossa of the ilium, and blending with the fibres of the psoas magnus it is inserted into the small trochanter and the surface of the femoral shaft immediately below this.

Gracilis.—This is a powerful broad muscular band which springs from the side of the pubic symphysis. This origin extends as high up as the antero-inferior angle of the marsupial bone, but in neither animal was the muscle in any way attached to this bone, as is the case in the majority of Marsupials. Indeed, Macalister[1] states that in every Marsupial that he has examined he has noticed an attachment of the gracilis to the marsupial bone. Young,[2] however, does not mention it in the Koala. In the *Cuscus* the gracilis (Pl. III. fig. 2, *g.*) has an extensive insertion into the anterior sharp ridge of the tibia in its middle third; in the *Thylacine* it presents a much more limited insertion into the subcutaneous surface of the tibia, a short distance below the internal tuberosity (Pl. IV. fig. 1, *g.*).

Pectineus.—In the *Cuscus* this muscle is more strongly marked than in the *Thylacine*. It presents in the former a small pointed origin from the anterior margin of the pubic bone, and also slightly from the outer and lower angle of the large marsupial bone. In the *Thylacine* it springs entirely from the cartilaginous nodule (Pl. III. fig. 1), that represents the marsupial bone, and is inserted into the femur, immediately below the small trochanter. In the *Cuscus* it expands, and has a linear insertion into the middle third of the posterior aspect of the shaft of the femur in front of the adductor brevis.

Triceps adductor.—In the *Thylacine* this muscular mass is divided as in man into three strata, but the ordinary terminology does not express the relative characters of these three strata; thus the adductor longus is the shortest muscle, the adductor brevis the bulkiest, and the adductor magnus the longest.

The adductor longus is very similar to the same muscle in man. It has a pointed origin from the base of the marsupial bone, and it expands as it passes downwards to be inserted into the middle third of the posterior aspect of the femur, where it is fused with the subjacent adductor brevis. The adductor brevis (Pl. IV. fig. 1, *a.b.*) has a wide origin from the pubic arch, and the anterior part of the ischial tuberosity. It is with difficulty separated from the adductor magnus, and it is inserted into the posterior aspect of the femur from the small trochanter above to the internal condyle below. Towards its lower part it is perforated by the femoral artery, as it passes backwards to enter the popliteal space. The adductor magnus (Pl. IV. fig. 1, *a.m.*) arises from the tuber ischii, under cover of the semi-membranosus and gracilis. It is not so bulky as the adductor brevis, and is inserted into the lower two-thirds of the posterior aspect of the shaft of the femur, and also by fleshy fibres into the inner aspect of the

[1] Ann. and Mag. Nat. Hist., vol. v., 4th ser.

[2] Journal of Anatomy and Physiology, vol. xvi.

internal condyle. Its lower margin, therefore, reaches lower down than that of the adductor brevis, and it is, in like manner pierced by the femoral artery (Pl. IV. fig. 1, *f.a.*). The quadratus femoris is in apposition with its upper border, whilst fused with it posteriorly are the lower fibres of the ischio-femoral muscle.

In the *Cuscus* (Pl. V. fig. 4) there are only two adductors present, viz., the adductor brevis and the adductor magnus. The absence of the adductor longus is rendered evident by the fact that the obturator nerve lies upon the superficial aspect of the adductor brevis.

The adductor brevis (*e*) is much the larger of the two muscles, and it completely hides the adductor magnus from the front. It has a curved origin from the base of the marsupial bone, and from the margin of the pubic symphysis, under cover of the gracilis (*f*). Its insertion is the same as the corresponding muscle in *Thylacinus*, and, like it, it is pierced by the femoral artery (e^1). The adductor magnus (*d*) is a thick fleshy strap, which arises from the arch of the pubis and the ischial tuberosity, and is inserted into the posterior aspect of the shaft of the femur in its lower third. It is not perforated by the femoral artery. The two muscles are easily separated from each other.

The triceps adductor is subject to considerable variations in the Marsupialia. Thus Macalister[1] records that the three portions are quite distinct in the Wallaby and Giant Kangaroo, whilst the adductor brevis and the adductor magnus are partially, or it may be completely, blended in the Opossum, *Sarcophilus*, Wombat, and in *Phalangista*.

Posterior Aspect of Leg.

The superficial muscles on the back of the leg are the gastrocnemius and the plantaris. In all probability the absent soleus is blended with the outer head of the gastrocnemius.

Gastrocnemius.—This muscle in *Thylacinus* arises by two very large and powerful heads. The outer head which contains the soleus is much the larger of the two, and it arises by two parts—(1) by a fleshy process fixed to a large sesamoid bone placed upon the posterior aspect of the head of the fibula, and from a powerful ligament which binds the upper part of this bone to the back of the external condyle of the femur; (2) by a tendinous slip attached to the outer aspect of the external condyle of the femur. The external popliteal nerve passes forwards between these slips of origin. The inner head, springs not only from the back of the internal condyle, but also from the whole breadth of the popliteal surface of the femur at the same level. The heads of the gastrocnemius join each other very shortly after their origin and the tendo achillis is inserted into the lower part of the posterior surface of the os calcis.

In the *Cuscus* the two heads of the gastrocnemius are separate throughout their entire length. The muscle therefore is present in the form of two distinct factors. The inner head (Pl. V. fig. 2, *b*) arises from the back of the internal condyle of the femur; it derives

[1] Ann. and Nat. Hist., vol. v., 4th series.

no fibres from the popliteal surface of the femur. Half-way down the leg, it gives place to a narrow tendon which has an independent insertion into the back of the os calcis (*b'*). The outer head has the same origin as in the *Thylacine*, with two exceptions, viz., (1) it has no tendinous slip attached to the outer aspect of the external condyle of the femur, and (2) it springs from the posterior aspect of the fibula in its upper two thirds through the medium of the intermuscular septum which intervenes between it and the peronei muscles. It is inserted by a strong tendon into the tuber of the os calcis, under cover of the tendon of the inner head (*a'*).

The fibular origin of the outer head of the gastrocnemius points very clearly to the fact that it is a compound muscle, and contains in its midst the fibres of the absent soleus. That the plantaris lies under cover of this muscle, is no proof against this view, and is certainly not evidence sufficient to lead one to look for the lost soleus amongst the deep muscles of the calf.[1] The plantaris is subjacent only to the inner part of the compound muscle, and does not lie under cover of the outer part which represents the soleus (Pl. V. fig. 2, *c*).

Plantaris.—In *Thylacinus* this muscle arises in common with the outer head of the gastrocnemius, and remains fused with its under surface for a considerable distance. It ends in a strong tendon which proceeds downwards along the inner side of the tendo achillis to the heel, where it expands, and, passing superficially to the tendo achillis, enters the sole. Here it spreads out in the form of a plantar fascia, which divides into three slips for the index, medius, and annularis. The plantar fascia is not attached to the subjacent muscles, and each of its terminal slips bifurcates to embrace the meta-tarso-phalangeal joint, and is attached to the ligamentous structures around this articulation.

In the *Cuscus* (Pl. V. fig. 2, *c*) the plantaris is a large muscle quite distinct from the soleo-gastrocnemius, although it lies under cover of its inner part. It arises from the sesamoid bone attached to the head of the fibula, and, passing over the tuber of the os calcis, it is inserted into a plate of cartilage in the sole which replaces the plantar fascia, and takes the place of the true heel.

This plantar cartilage (Pl. VI. fig. 5, *p.c.*) possesses very definite relations. Internally it is attached to a sesamoid bone which glides upon the internal cuneiform, and gives attachment to some of the short muscles of the hallux; externally it is fixed to the under surface of the cuboid, and here it gives origin to some of the short muscles of the minimus; posteriorly the plantaris tendon (*p.t.*) is inserted into it; whilst in front it is prolonged forward in the form of fascial slips, to the roots of the digits.

The plantaris is almost invariably present amongst the Marsupials. It is absent however in the Wombat.[2]

[1] Young, Muscular Anatomy of the Koala, p. 237, Jour. Anat. and Phys., vol. xvi.

[2] Macalister, *loc. cit.*, p. 3.

The deep muscles on the back of the leg show very material differences in the two animals.

Tibialis posticus.—In the *Thylacine* this muscle is small in size and intermediate in position between the flexor longus hallucis and the flexor longus digitorum. It has apparently no direct bony attachment at its origin, but springs from the fascia which covers the popliteus, whilst externally it is inseparably connected with the flexor longus hallucis. At the inner ankle its tendon passes under cover of that of the flexor longus digitorum, and proceeds along the inner margin of the foot to be inserted into the internal cuneiform bone, and into the base of the first metatarsal bone.

In the *Cuscus* the tibialis posticus is apparently double. The largest or internal part (Pl. V. fig. 2, *f*) occupies the position of the flexor longus digitorum which is absent. It arises by two heads—a tibial and a fibular. The latter springs from the posterior aspect of the head of the fibula, and its fibres which pass obliquely downwards and inwards are partially fused with the upper part of the subjacent popliteus. The tibial head takes origin from the upper half of the posterior surface of the tibia, and after being joined by the oblique fibular fibres, the muscle gives rise to a tendon which passes over a groove on the back of the internal maleolus to reach its insertion into the inner aspect of the scaphoid bone. It is possible that this muscle may be the representative of the flexor longus digitorum, but it is difficult to reconcile this view with its tarsal insertion.

The smaller and external part of the muscle (Pl. V. fig. 2, *g*) is a very minute fleshy belly, which lies deeply under shadow of the huge flexor muscle, and arises from the head of the fibula and the fascia over the popliteus. Its slender tendon passes over the groove on the back of the internal maleolus, under cover of the tendon of the preceding muscle, and is inserted into the plantar aspect of the scaphoid bone.[1]

Flexor muscles.—In the *Thylacine* there is a small flexor longus digitorum and a large flexor longus hallucis; in the *Cuscus* the flexor longus digitorum is apparently absent, but the flexor longus hallucis is a huge muscle, and it gives off from its superficial surface, whilst still in the leg, the representative of the flexor brevis digitorum.

The flexor longus digitorum in the *Thylacine* springs from the posterior aspect of the shaft of the tibia in its upper two-thirds, and also by a pointed and separate process from the back of the internal tuberosity of the tibia and the posterior ligament of the knee-joint. At the inner ankle it crosses the tendon of the tibialis posticus obliquely, and entering the sole ends by joining the large tendon of the flexor longus hallucis.

The flexor longus hallucis is a very large and powerful muscle. It occupies the outermost place of the deep muscles on the back of the leg, and it takes origin from the whole length of the posterior surface of the fibula. The thick rope-like tendon in which it ends enters the sole by passing forwards in a groove on the back of the astragalus, and after

[1] Young notes that the tibialis posticus is double in the Koala, *loc. cit.*, p. 41.

being joined by the tendon of the flexor longus digitorum, it splits into four, viz., a tendon for each toe.

In the *Thylacine* a small flexor brevis digitorum is found in the sole of the foot. It lies under cover of the expanded tendon of the plantaris, and springs from the inner aspect of the os calcis close to its posterior extremity. Four delicate tendons issue from it, and these pass downwards for a short distance in a groove on the superficial aspect of the large tendon of the flexor longus hallucis, and then diverge to reach their respective digits. The insertion of the flexor tendons upon the plantar face of the digits is effected in the usual manner.

We must now look at the arrangement of the huge flexor mass on the posterior aspect of the leg of the *Cuscus*. It occupies the place of the flexor longus hallucis, and arises from the whole length of the posterior aspect of the fibula as in the *Thylacine*, and also from the fascia covering the popliteus. About the middle of the leg it divides into two, viz., (1) a small superficial portion (Pl. V. fig. 2, *e*), and (2) a large deep part (Pl. V. fig. 2, *d*). These bear to each other very much the same relation that the flexor sublimis in the fore-arm of the same animal bears to the flexor profundus. The sublimis or superficial part ends in three tendons, and is the representative of the flexor brevis digitorum. It is interesting to note that it is supplied by a recurrent branch from the internal plantar nerve, whilst the profundus or deeper part is supplied by a twig from the internal popliteal nerve. The profundus ends in a rope-like tendon, which is grooved for the reception of the three delicate tendons of the flexor brevis digitorum. In the sole it divides into five tendons—one for each toe. The three tendons of the flexor brevis digitorum go to the minimus, annularis, and medius, and are pierced by the deep tendons.[1]

Lumbricales.—In the *Cuscus* these are four in number, and with the exception of that for the index they are very large, and expand so much towards their insertions that their attachment extends along the whole length of the first phalanx. Pl. III. fig. 1, *l*. shows the lumbrical of the annular digit.

In the *Thylacine* the lumbrical muscles are peculiar. Each muscle is double, so that one arises from each side of the deep flexor tendon and envelopes it completely in sparse muscular fibres. Again, they are not inserted into the dorsal extensor expansion but are attached to the flexor sheaths of the digits—two to each toe.

Popliteus (pronator tibiæ).—This muscle consists of a continuous layer of oblique fibres which occupies the entire interosseous space. It is thick and fleshy in its upper and lower thirds, but its middle third is very thin, and has a large admixture of tendinous fibres entering into its composition. The fibres of the muscle pass from the fibula obliquely downwards and inwards to the tibia.

In the *Cuscus*, in which the interspace between the bones is wide and the movement of the fibula peculiarly free, the attachment of the muscle in different planes (so well

[1] There is no musculus accessorius in the foot of either *Thylacinus* or *Cuscus*.

described by Dr. Young in the Koala[1]) is very evident. The upper thick fleshy mass is fixed on the one hand to the posterior surface of the tibia and on the other to the antero-internal border of the fibula. A few very oblique and superficial fibres arising from the external lateral ligament of the knee-joint evidently represent the popliteus proper, the rest of the muscle being the pronator tibiæ of Humphry. The lower thickening of the muscle is fixed to the antero-external surface of the tibia.

The movements of the fibula upon the tibia at the tibio-fibular joints cannot in any respect be compared to those of pronation and supination in the forearm. Young, in his admirable paper upon The so-called Movements of Pronation and Supination in the hind-limb of certain Marsupials,[1] has already pointed out that the "tibio-fibular articulations admit of movements in the antero-posterior directions only; these movements are simply those of gliding and coaptation." He also shows how the attachment of the interosseous muscle on different planes affects this movement; the upper portion of the muscle producing "a backward and inward movement of the upper end of the fibula," whilst the lower fibres by their contraction draw the lower end of the bone inwards and forwards, or in other words, when the whole muscle contracts, the fibula is "thrown obliquely across the tibia" and approximated to it. From a study of the pronator tibiæ muscle, and the tibio-fibular articulations in the *Cuscus*, I can verify Dr. Young's results.

In the *Thylacine* the movement of the fibula upon the tibia is extremely limited, but of precisely the same character as in the *Cuscus*. The pronator tibiæ muscle is, however, very well developed, but owing to the close apposition of the bones, the fibres are exceedingly short. It shows the same thickening in its upper and lower portions, and below it is chiefly seen from the anterior aspect of the limb, owing to the tibial attachment of the fibres being so far forward upon the bone.

As in the Koala, the tibia and fibula in the *Cuscus* are separated at the lower tibio-fibular articulation by a fibro-cartilage, which juts upwards between them from the ankle-joint. In *Thylacinus*, however, the lower ends of the bones are in direct apposition, and both surfaces are coated with encrusting cartilage.

Anterior and Outer Aspects of the Leg.

In the *Cuscus* there are three well-defined muscles upon the anterior aspect of the leg, viz., the tibialis anticus, the extensor longus hallucis, and the extensor longus digitorum. These muscles occupy the same relative position as in man. In *Thylacinus* the extensor longus hallucis is absent.

Tibialis anticus (Pl. V. fig. 3, *f*).—This is a very powerful muscle in both animals; it

[1] Jour. Anat. and Phys., vol. xv. p. 393.

springs from the outer tuberosity and the outer surface of the shaft of the tibia and from the interosseous membrane. In the *Cuscus* it is inserted into the plantar aspect of the internal cuneiform bone and the base of the first metatarsal bone; in the *Thylacine* it is inserted into the base of the metatarsal bone of the index.

Extensor longus hallucis (Pl. V. fig. 3, g').—This is present only in *Cuscus*, and is a well-developed muscle, which lies almost completely under cover of the extensor longus digitorum. It arises from the anterior prominence of the head of the fibula, from the inner border of the fibula in its upper half and from the interosseous membrane. It makes its appearance by passing forwards between the tibialis anticus and the extensor longus digitorum, and its tendon is inserted into the ungual phalanx of the hallux. In some Marsupials, according to Professor Macalister,[1] this muscle is inserted by two tendons into the hallux and index, viz., Wallaby, Oppossum, *Phalanger*.

Extensor longus digitorum (Pl. V. fig. 3, *e*).—In the *Cuscus* this muscle has a very limited origin from the anterior prominence of the head of the fibula, from the outer tuberosity of the tibia, and from a ligament which bridges across between these two bony projections. In the *Thylacine* its orgin is much more extensive, viz., from the anterior aspect of the head of the fibula, from the inner surface of the same bone in its upper two thirds, and also from a corresponding portion of the interosseous membrane.

In the *Cuscus* the muscle ends in three tendons. Of these one (the intermediate) goes to the ring digit, the outermost to the little toe, whilst the innermost divides into two for the index and medius. Each of the lateral tendons sends a slip to strengthen that for the large ring digit.

In the *Thylacine* four tendons are given off by the extensor communis digitorum, and these are inserted in the following manner:—(1) The outermost is inserted into the minimus, (2) the second (counting from the outer margin of the foot) divides and sends a slip to the annularis and medius, (3) the third also divides for the medius and index, (4) whilst the fourth goes to the index alone.

Peroneal muscles—This group of muscles comprises in each case (1) the peroneus longus, (2) the peroneus brevis, and (3) certain fleshy slips which represent portions of the extensor brevis digitorum.

Peroneus longus.—This is a very powerful muscle in the *Cuscus* (Pl. V. fig. 3, a^1 and a^2), in the *Thylacine* it is not so strongly developed. In both it springs by two heads which are separated from each other by the anterior tibial nerve. In *Cuscus* the one head of the peroneus longus, a broad flat band, is superficial to the other, and springs from the anterior and posterior prominences on the head of the fibula and from the external lateral ligament of the knee-joint; the deep head arises from the outer aspect of the shaft of the fibula in its upper half. A strong tendon (Pl. V. fig. 3, a') issues from the muscle; this passes downwards behind the external maleolus to the outer margin of the foot, where

[1] *Loc. cit.*, p. 3.

it turns round a deep groove in the cuboid, and is directed inwards across the sole. It is inserted into the base of the first metatarsal bone. Two annular ligaments confine the tendon in its passage downwards, viz., behind the external maleolus and upon the outer aspect of the os calcis. In the sole of the foot it is not provided with a complete sheath.

In *Thylacinus* the peroneus longus presents an origin very similar to that in *Cuscus*. Its tendon, however, is inserted into the ento-cuneiform bone, and as it winds round the outer margin of the foot it is slightly attached by tendinous fibres to the base of the fifth metatarsal bone.

Dr. Georg Ruge,[1] in his elaborate memoir upon the extensor muscles of the leg and foot, expresses his belief that the insertion of the peroneus longus into the inner margin of the foot does not present the original condition of the muscle. To explain the course of the tendon across the sole of the foot he advances the hypothesis that the original insertion of the tendon was into the base of the fifth metatarsal, and that its progress inwards has been caused by the fibres of insertion coming more and more into relation with the plantar ligaments. In support of this theory he points to the *Monotremata*, in which the tendon does not lie free in a sheath during its passage through the sole, but is connected by thin membranous slips to the cuneiform bones, and in which also the tendon is attached by a process containing half its fibres to the base of the fifth metatarsal. In the *Didelphys virginiania*, *Didelphys cancrivora*, and the *Dasyurus hallucinatus* he likewise noticed an attachment of the tendon of the peroneus longus to the tuberosity on the base of the fifth metatarsal bone, whilst in the first of these animals it presented additional attachments to the bases of the third and fourth metatarsal bones.

In *Cuscus* the tendon (Pl. VI. fig. 6, *p.t.*) lies quite free in its sheath, and has no other attachment except to the base of the first metatarsal bone; in *Thylacinus*, as we have seen, it is slightly attached to the base of the fifth metatarsal bone.

Peroneus brevis.—In the *Cuscus* (Pl. V. fig. 3, *b*) this muscle arises by a narrow pointed tendon from the anterior prominence of the head of the fibula; it likewise derives fibres from the intermuscular septum between it and the extensor communis digitorum. In the *Thylacinus* it also takes origin from the shaft of the fibula in its upper half, and in both animals it is inserted into the base of the fifth metatarsal by a tendon which runs downwards behind the external maleolus and then along the outer margin of the foot.

It seems to be the rule for this muscle to take origin from the shaft of the fibula as in the *Thylacine*. Ruge[1] describes this in the *Didelphys virginiana*, *Didelphys cancrivora*, and in *Dasyurus hallucinatus*. Dr. Ruge believes that the peroneus brevis is originally derived from the outermost belly of the extensor brevis digitorum.

[1] A Research into the Group of Extensors of the Leg and Foot of Mammalia, Morph. Jahr., 1880.

Extensor brevis digitorum.—In the memoir by Ruge, to which reference has been made, the author traces with great ability the history of this muscle. It belongs originally to the peroneal group of muscles, and in the *Monotremata* it may be observed to arise entirely from the fibula. Its progress as it passes down to the dorsum of the foot can be traced step by step through the mammalian series. First one belly descends, then another, and so on until the entire muscle gains the dorsum of the foot, as in man.

In *Thylacinus* the entire muscle arises from the fibula ; in the *Cuscus* the part belonging to the medius and index has reached the dorsum of the foot, whilst that belonging to the two outer digits still shows a fibular origin.

In the *Thylacine* the extensor brevis digitorum is represented by three separate fleshy bellies, all of which arise from the fibula under cover of the two peronei muscles. The largest of these fleshy bellies springs from the upper third of the fibular shaft, and its tendon joins the dorsal expansion of the extensor tendon of the little toe ; the other two arise side by side from the middle third of the fibular shaft, and of these the posterior belly gives rise to a tendon which divides to reach the extensor expansions of the index and middle digits, whilst the anterior belly sends its tendon to the extensor expansion of the ring toe. All these tendons accompany the tendons of the peronei muscles behind the external maleolus.

In the *Cuscus* the fibular portions of the extensor brevis digitorum are two in number, viz., (1) a good sized muscle (Pl. V. fig. 3, *c.*) which arises from the outer aspect of the head of the fibula, under cover of the superficial head of the peroneus longus ; the slender tendon of this fleshy slip passes behind the external maleolus, and is inserted into the dorsal expansion of the extensor tendon of the minimus (c^t.) ; (2) the second fleshy belly (Pl. V. fig. 3, *d*) is subjacent to the preceding, and springs from the middle third of the inner aspect of the shaft of the fibula ; its tendon passes behind the external maleolus and gaining the dorsum of the foot is inserted into the extensor expansion of the ring digit (d^t.)

The pedal portion of the extensor brevis digitorum in the *Cuscus* (Pl. V. fig. 3, *h*) arises by a narrow tendon from the outer aspect of the os calcis. It is a very minute fleshy band, which ends in two delicate tendons for the index and medius respectively.

In the Koala[1] the arrangement of the extensor brevis digitorum is similar to that of the same muscle in the *Cuscus.*

According to Ruge[2] the fibular portion of the muscle in *Didelphys* and *Dasyurus* consists of two fleshy bellies, of which one sends a tendon to the fifth toe, whilst the other supplies tendons to the second, third, and fourth toes; further, in *Didelphys* there is a pedal portion which is devoted solely to the hallux and index.

[1] Young, *loc. cit.*, p. 41.

[2] *Loc. cit.*, p. 46.

INTRINSIC MUSCLES OF THE MAMMALIAN FOOT.

We have seen that the intrinsic muscles of the manus of certain of the Marsupialia (*vide* p. 19) may be considered to be disposed in three layers according to the plane which they occupy as we dissect from the palmar to the dorsal aspect of the hand. Each digit is provided with three muscles, each of which exercises its own independent action upon it. It derives an adductor from the palmar layer, an abductor from the dorsal layer, and a flexor brevis from the intermediate layer. The medius is usually an exception to this rule, inasmuch as two of its muscles belong to the dorsal layer.

In making inquiry into the arrangement of the corresponding muscles of the pes, I have extended my investigations over a much wider area. In the case of the manus my observations, with a very few exceptions, were restricted to members of the Marsupial order; in the case of the pes I have examined a large number of different mammalian feet, and with very interesting results. From the Challenger Expedition Commission I received for this purpose one specimen of each of the following animals:—(1) the Dingo or Australian Wild Dog, (2) *Hyrax capensis*, (3) *Ornithorhynchus paradoxus*, (4) *Mus capensis*, (5) *Bathyergus capensis*, (6) *Felis concolor*. The other specimens which I have had an opportunity of examining were for the most part supplied from the stores of the Anatomical Museum of the Edinburgh University, which Professor Turner, with his usual kindness, placed at my disposal.

Definition of the term "intrinsic."—The term "intrinsic" as applied to the muscles of the foot can best be defined by a process of exclusion—by naming those muscles which it does not include. These are—

1. The accessorius and lumbricales. 2. The flexor brevis digitorum.
3. The extensor brevis digitorum.

The accessorius and lumbricales cannot be regarded as independent muscles. They are simple accessory parts of the flexor longus digitorum and must therefore be classed with it. The flexor brevis digitorum is the homologue of the flexor sublimis of the forearm, and in some animals it may be seen taking origin beyond the limits of the foot in common with the flexor longus digitorum. The extensor brevis digitorum is excluded for the same reason. The history of this muscle has already been referred to (p. 47). Originally a peroneal muscle, it comes to lie in a number of animals upon the dorsum of the foot.

In the human foot, therefore, the intrinsic muscles are the following:—

a. The four short muscles of the great toe, .
1. Flexor brevis hallucis.
2. Abductor hallucis.
3. Adductor hallucis (adductor obliquus).
4. Transversalis pedis (adductor transversus).

b. The short muscles of the little toe,	1. Flexor brevis minimi digiti. 2. Abductor minimi digiti. 3. The occasional opponens minimi digiti. 4. The occasional abductor ossis metatarsi minimi digiti.
c. The interossei,	1. Four dorsal. 2. Three plantar.

The determination of muscle homologies.—In tracing the history of any muscle or group of muscles the characters upon which most dependence is to be placed are clearly: (1) the position, (2) the insertion, (3) the nerve supply. Not one of these, however, can be looked upon as an infallible guide. The insertion, inasmuch as it involves the action or function of a muscle more than the origin, is of considerably greater importance. The origin, and in a corresponding measure, the position of a muscle are changeable features upon which we cannot place much reliance. The best example which can be given of this is the descent of the different bellies of the extensor brevis digitorum from the fibular aspect of the leg to the dorsum of the foot. Still in the group of muscles with which we have to deal instances of the same kind are by no means infrequent. Thus the marginal intrinsic muscles of the foot (*i.e.*, the abductor minimi digiti and abductor hallucis) show an invariable tendency to extend backwards to the os calcis for their origin, and, when the hallux or minimus is absent, the dorsal interosseus which thus becomes marginal commonly exhibits a like tendency unless it be confined by a rudimentary metatarsal. The adductors perhaps more than any other members of the intrinsic group tend to shift their origin according to the requirements demanded of them. The character of these changes will be fully discussed later on.

Dr. Georg Ruge of Heidelberg insists strongly upon the invariable and immutable relationship between nerve supply and muscle homology. He asserts with Gegenbaur that a muscle is to be regarded as the end-organ of a nerve, and therefore when a muscle alters in position and connections its original and typical relations can always be identified by its nerve of supply.[1] That this is a most valuable aid in our endeavours to discover the history of a muscle no one will deny; but that it is an infallible guide is a view which is contrary to fact. We shall afterwards have occasion to refer to this.

Recognising, then, the importance of the nerve supply as a guide in the determination of muscle homology, I have, in the present inquiry, examined the plantar nerves in connection with the muscles in as many cases as it was possible to do so.

In the human foot we find that the abductor hallucis and the flexor brevis hallucis are supplied by the internal plantar nerve, whilst all the other intrinsic muscles receive their nerve supply from the external plantar nerve. The second and first dorsal interossei sometimes receive additional nerve fibres from the anterior tibial nerve on the

[1] Processes in the Development of the Muscles of the Human Foot, Morphologisches Jahrbuch, 1878, p. 137.

dorsum of the foot.[1] Ruge accounts for this peculiarity by looking upon the second and first interosseous muscles in these cases as being compound muscles,—receiving accessory heads from the extensor brevis digitorum. The nerve filaments which go to them, from the anterior tibial, are therefore for the supply of these extraneous fibres.[2]

Conclusions Regarding the Dispositions of the Intrinsic Muscles.

I. That the typical arrangement of the intrinsic muscles of the pes is the same as in the hand, and that this arrangement is seen to best advantage in the feet of certain of the Marsupialia. In these animals the muscles are disposed in three layers :—

1. A plantar layer of adductores.
2. An intermediate layer of flexores breves.
3. A dorsal layer of abductores.[3]

Fig. 1. Schematic view of a section through the metatarsus of a typical foot.

(I. to V.) Metatarsal bones. (p^1 to p^5) Plantar layer of adductores. (f^1 to f^5) Intermediate layer of flexores breves. (d^1 to d^5) Dorsal layer of abductores. (*e.p.n.*) External plantar nerve.

Deviations from this typical trilaminar disposition may take place—(*a*) by subdivision of certain of the members of one or other of the layers, (*b*) by fusion of certain of the elements of the different strata, or (*c*) by suppression or non-development of some of the muscles.

The first of these deviations is to be found in a few Marsupial animals, in which a tendency is exhibited to the development of a fourth layer of muscles by the splitting

[1] Rudinger Die Gelenknerven des Menschlichen Körpers, Erlangen, 1857. Cunningham, Journal of Anatomy and Physiology, vol. xiii.

[2] *Loc. cit.*, p. 50.

[3] Professor Humphry, in his Memoir upon the Myology of the *Orycteropus capensis* (Jour. of Anat. and Phys., May 1868), alludes in a footnote to this typical arrangement, and singles out the Rabbit as affording a good example. In this animal, however, the dorsal and intermediate muscles have undergone fusion, and it does not exhibit the trilaminar disposition so well as the marsupial hand or foot.

of the dorsal interossei. Fusion of the constituents of the intermediate and dorsal layers is extremely common, whilst fusion between the plantar and intermediate muscles is a very rare occurrence. Suppression of certain of the muscles may take place in two ways. It may either be complete—not a trace of the lost muscle being left—or partial, in which case the place of the missing muscular belly is taken by a ligamentous structure, having the same connections, and probably a distinct function to play in the mechanism of the foot.

II. The presence of an opponens muscle is not accounted for in the foregoing disposition of the intrinsic muscles. When present, it may be regarded as being derived from one or two sources. Most commonly it is a development from the flexor brevis, but it may proceed, as in many of the Carnivora, from the plantar layer, and thus be associated with the adductors.

III. The last point which I am anxious to prove is, that in many animals, the relation of the intrinsic muscles to the metatarsal bones, both as regards their origin and position, corresponds with transitory conditions in the foot of the human embryo.

Let us take up the first of these generalisations, and examine the facts upon which it is founded.

Marsupialia.

Thylacine (Pl. VI. figs. 1, 2).

The pes of this animal closely resembles that of the Dog. The hallux is suppressed, but in connection with the remaining four digits the typical disposition of the intrinsic muscles in three layers is very manifest.

The plantar layer (p^2, p^4, p^5) consists of three muscles, which have as their function the adduction of the toes, towards a line drawn through the medius. They are—

1. Adductor indicis (p^2).
2. Adductor annularis (p^4).
3. Adductor minimi digiti (p^5).

The adductor indicis and the adductor minimi digiti arise in the middle line of the foot by a single pointed origin from the fibrous structures at the base of the metatarsus. Separating and then diverging from each other the former is inserted upon the fibular side of the base of the proximal phalanx of the index, whilst the latter is inserted upon the tibial side of the base of the corresponding phalanx of the minimus. In both cases the insertion is partly into the sesamoid bone, and partly into the extensor tendon on the dorsum of the digit. In some cases the adductor indicis is double (*vide* fig. 1).

The adductor annularis springs from the base of the middle metatarsal, under cover of the two preceding muscles, and swelling out into a fusiform belly, it is inserted upon the tibial side of the proximal phalanx of the annular digit in a manner similar to the other adductor muscles.

Intermediate layer (f^2 to f^5).—The muscles composing this layer are four in number, and are placed one upon the plantar surface of each metatarsal bone, but further, each muscle consists of two slips, which may arise separately, or by a common origin from the base of the metatarsal bone with which they are associated. No definite rule seems to apply to their mode of origin. In the feet of the same animal the muscle of any given digit may be seen arising in the one pes by two heads, whilst in the other it may take origin by a single head. At the root of the toe the two slips embrace the base of the proximal phalanx, and are inserted one into each sesamoid bone, and sometimes also into the extensor tendon as well.

These muscles, then, are true flexores breves when the two slips act in unison. When they act independently of each other, however, they exercise an abducting or adducting influence, according to the slip employed.

The *dorsal layer* (d^2 to d^6) includes the abductor minimi digiti, the abductor ossis metatarsi minimi digiti, and the four dorsal interossei.

The abductor minimi digiti ($d^{6\prime}$) is a small fleshy slip which arises from the outer aspect of the tuberosity of the os calcis, and soon ends in a long narrow tendon. This is inserted into the extensor tendon of the minimus on the fibular side of the first phalanx.

In the foot of the large male *Thylacine* an additional abductor of the little toe was present. This consisted in an exceedingly minute fasciculus ($d^{6\prime\prime}$), which took origin from the base of the metatarsal, and extended downwards upon the surface of the outer head of the flexor brevis to its insertion into the outer sesamoid bone.

The abductor ossis metatarsi minimi digiti (d^6) is a strongly marked muscle which springs from the outer aspect of the tuberosity of the os calcis in common with the abductor minimi digiti. It presents the usual insertion into the base of the fifth metatarsal bone.

The splitting up of the abductor of the little toe into three parts points to the usual triple insertion of this muscle (viz., into the metatarsal bone, into the sesamoid bone, and into the dorsal expansion of the extensor tendon), and indicates a tendency for the fibres belonging to each of these insertions to separate and constitute a distinct muscle. The abductor metatarsi is very constant throughout the mammalian series, but it is rare to find the other two parts separate. In the *Cuscus*, however, it is even more evident than in the *Thylacine*.

The dorsal interossei.—The first dorsal interosseus or abductor indicis, owing to the absence of the hallux, is marginal in its position, and therefore more highly developed than the others. It consists of two parts (fig. 2, d^2, and $d^{2\prime}$). Of these one arises from the base of the metatarsal, in common with the inner head of the flexor brevis indicis, and is inserted into the inner sesamoid bone; the other wanders backwards for its origin (thus exhibiting the usual tendency of a marginal muscle), and springing from the scaphoid is inserted into the extensor tendon on the inner aspect of the index.

The remaining three dorsal interossei (fig. 2, d^3 to d^5) cannot be properly studied unless we throw forward both the plantar and intermediate muscles. They are then seen to be prismatic, one-headed muscles, lying in the interosseous spaces, but only reaching for a short distance upwards between the bones; indeed they are more plantar than dorsal in their relation to the metatarsus. They spring from the bases of the metatarsal bones, and are inserted so as to abduct the toes from a line drawn through the medius. The second and third, therefore, are appropriated by the medius, whilst the fourth is set aside for the annularis. They correspond, therefore, in their insertions with the same muscles in the human hand.[1]

Dasyurus viverrinus (Pl. XI. figs. 5–6).

The foot of this animal is long and narrow. The hallux is very rudimentary, consisting merely of a short metatarsal, which is only evident in the undissected condition of the pes as a slight protuberance on its inner margin. The other four digits are well developed, and of nearly equal length.[2] The metatarsal bones are placed in such close apposition that when the foot is viewed from its dorsal aspect, not a single intrinsic muscle is apparent. They are all crowded into the sole, but, in spite of this, they exhibit in a marked manner the typical trilaminar disposition, each of the four well-developed toes being provided with three separate intrinsic muscles.

Plantar layer (fig. 5, p^1 to p^5).—In this layer we find four muscles which act so as to draw the digits into which they are inserted towards a line drawn through the medius. They are—

1. Adductor hallucis (p^1).
2. Adductor indicis (p^2).
3. Adductor annularis (p^4).
4. Adductor minimi digiti (p^5).

The adductor indicis and adductor minimi digiti are the most strongly marked. They together constitute an exceedingly thin triangular sheet of fibres which lies superficial to the other muscles. This muscular sheet takes origin by its apex which is tendinous, in the middle line of the foot, from the ligaments which bind the metatarsus to the tarsus. Its base arches over the bases of the annularis and medius, and it is inserted by its angles into the index and minimus—in the case of the former into the outer sesamoid bone at its base, and in the case of the latter, into the inner sesamoid bone. The separation of the two muscles is indicated by a faint fibrous raphe which traverses the triangular muscular sheet from the apex to the centre of its arched base.

The adductor annularis is a minute fusiform fleshy slip which arises from the deep surface of the raphe which separates the two preceding muscles. The muscular sheet com-

[1] In the feet of the small female *Thylacine* a slight tendency to fusion between the flexores breves, and the dorsal interossei was exhibited. In the large male, however, they were quite distinct.

[2] In Waterhouse's well-known work upon Mammalia, an excellent figure of this foot is given in vol. i. pl. xii. fig 1.

posing these muscles is so thin that this small fasciculus can be seen shining through the fibres. Emerging from under cover of the arched lower border of the combined muscles it is inserted into the inner sesamoid bone at the base of the proximal phalanx of the annularis.

The adductor hallucis is a delicate little muscle which springs from the base of the metatarsus, close to the inner side of the conjoined origin of the adductors of the index and minimus. It is inserted into the outer side of the head of the metatarsal bone of the rudimentary hallux.

In a recent paper by Ruge,[1] upon the comparative anatomy of the deep muscles of the sole of the foot, the author describes and figures in the *Dasyurus hallucatus*, a special adductor of the medius. This muscle does not exist in the foot of the *Dasyurus viverrinus*, and its presence in the specimen which Dr. Ruge dissected is somewhat difficult to understand, seeing that it is rare for the digit which constitutes the centre for the movements of adduction and abduction to be supplied with a special adductor. Ruge considers it to be a link which binds this animal with the *Ornithorhynchus paradoxus*, the pedal muscles of which have a very remarkable arrangement.

Intermediate layer (fig. 6, f^1 to f^5).—Very little need be said regarding the muscles which compose this layer. Each of the four outer toes is provided with a flexor brevis, which is quite distinct from the dorsal interossei, and shows no tendency to fuse with them, notwithstanding their close proximity, from the more or less complete obliteration of the inter-metatarsal spaces. Each muscle arises from the base of the metatarsal bone upon which it lies, and soon divides into two slips. These embrace the root of the corresponding toe, and are inserted one into each sesamoid bone. The flexores breves are very similar, therefore, to the same muscles in *Thylacinus*—differing only in the two heads of each muscles springing in all cases by a common origin.

In addition to the adductor hallucis, the rudimentary hallux is provided with a small fleshy slip (figs. 5 and 6, f^1t), which arises from the scaphoid, and is inserted into the inner side of the head of the metatarsal bone. The question naturally arises—What is this muscle? Is it a flexor brevis or an abductor? It is supplied by the internal plantar nerve, but this does not help us in our difficulty, seeing that both these muscles usually derive their nerve fibres from this source. Ruge apparently considers it to be the abductor hallucis, as he marks it in the figure of the foot of the *Dasyurus hallucatus* (*a.h.*), but I think it is more likely that it represents both muscles fused into one. My reason for this belief is, that in *Phascogale*, in which the hallux is slightly better developed, the two muscles are distinct from each other although in very close proximity.

The *dorsal layer* consists of—(1) the abductor ossis metatarsi minimi digiti ($d^{6\times}$), (2) two abductors of the little toe (d^6 and $d^{6'}$), (3) four dorsal interossei (figs 5 and 6, d^2 to d^5).

The abductors of the little toe are three in number, and arranged in a manner very similar to those of the *Thylacine*. The muscle which is inserted into the sesamoid ($d^{6'}$)

[1] Dr. Georg Ruge, Zur vergleichenden Anatomie der teifen Muskeln in der Fussohle, Morph. Jahrbuch, 1879.

takes origin further back, however, from the under surface of the projecting base of the fifth metatarsal bone. It is a very minute although perfectly distinct slip, and it is rendered all the more apparent from the fact that the deep division of the external plantar nerve (*d*), as it turns inwards, passes under cover of it. In *Dasyurus hallucatus* Ruge[1] both figures and describes this slip with great exactitude. In his specimen, however, it did not attain an independent insertion, but blended with the outer head of the flexor brevis.

The four dorsal interossei are plantar in position. They are one-headed muscles which arise from the bases of the four outer metatarsal bones, and are inserted as in *Thylacinus*, so as to abduct the digits from a line drawn through the medius. This digit, therefore, is supplied with two, viz., the second and third.

Phascogale calura.

The foot of this animal in external characters closely resembles that of the *Dasyurus viverrinus*. The hallux, however, is more strongly developed; still it is not furnished with a nail or claw, nor is it nearly so long as the other four digits.[2] The metatarsals are placed so close to each other that all the intrinsic muscles are situated in the sole. The trilaminar arrangement is nevertheless very manifest.

Plantar layer.—This layer is composed of four muscles, all of which lie upon one plane. They are—

1. Adductor hallucis.
2. Adductor annularis.
3. Adductor indicis.
4. Adductor minimi digiti.

These muscles are inserted so as to adduct the digits with which they are connected towards the medius.

The adductor indicis, adductor annularis, and adductor minimi digiti all spring by a common tendinous origin from the base of the metatarsus in the middle line of the foot. This soon expands into a thin fleshy sheet which lies upon the other intrinsic muscles. Near the roots of the toes it divides into three slips which diverge from each other to reach their respective points of insertion.

The adductor hallucis has an independent origin from the base of the metatarsus, upon the inner side of the common tendon of the other three adductors. It is inserted into the outer aspect of the first phalanx of the hallux.

Intermediate layer.—The four outer toes are each provided with a double-headed flexor brevis, and these muscles have an arrangement similar in every respect to that of the corresponding muscles in *Dasyurus*.

The hallux also is furnished with a flexor brevis, which in this case is quite distinct from the abductor. The inner or tibial head, however, alone is present.

Dorsal layer.—In this layer we find (1) the abductor ossis metatarsi minimi digiti,

[1] *Loc cit.*, p. 54.

[2] In Waterhouse's Mammalia a figure of the foot of *Phascogale penicillata* is given (pl. xii. vol. i.).

which has precisely the same connections as in the two preceding animals; (2) the abductor minimi digiti, which in this case is single; (3) four dorsal interossei, which are arranged similarly to the corresponding muscles in *Dasyurus;* (4) the abductor hallucis, which arises from the base of the first metatarsal bone, and is inserted into the outer side of the base of the proximal phalanx. It lies in close contact with the flexor brevis hallucis, but is easily separable from it.

Cuscus maculata (Pl. V. fig. 1, and Pl. VI. figs. 5, 6).

The foot of this animal in the undissected state is seen in Plate V. fig. 1. The hallux is a broad powerful digit placed at right angles to the long axis of the foot, so as to oppose the other toes. It is not furnished with a claw, and is curved somewhat towards the sole. The index and medius are poorly developed, and are enveloped in a common integumental covering as far down as the second phalangeal joints. Independent movement of these digits, therefore, is rendered impossible. Of the four outer toes the annularis is much the largest. In every respect this foot is admirably adapted for grasping the boughs of the trees in which the animal passes its existence.

The position of the hallux, so far apart from the other toes, somewhat disconcerts the typical arrrangement of the muscles in so far as this digit is concerned. Still, sufficient indications remain to justify the conclusion that its three muscles, viz., the abductor, flexor brevis, and adductor belong one to each of the three layers that are here laid down as typical.

The *plantar layer* (fig. 5 p^1 to p^5) consists of three muscles, viz. :—

1. Adductor hallucis (p^1).
2. Adductor minimi digiti (p^5).
3. Adductor annularis (p^4).

The adducting muscles of both manus and pes of all animals show a strong tendency to place themselves obliquely or even at right angles to the digit upon which they operate. In this manner they obtain a more powerful adducting influence. In the feet of the *Thylacine*, *Dasyurus*, and *Phascogale* we have seen these muscles seek the middle line for their origin, and from this they radiate towards their insertions. In *Phascogale* they all lie upon the same plane, but in *Thylacinus* and *Dasyurus* the adductors of the index and minimus in pressing inwards, have thrust the adductor of the annularis upwards, and have thus come to coalesce and lie superficial to it (*vide* Pl. VI. fig. 1, and Pl. XI. fig. 5). Again, in the human foot we see the transversus pedis placing itself at right angles, and the adductor hallucis obliquely in relation to the great toe. But still more striking examples are to be observed in the hand and more especially in the foot of the *Cuscus*. In the hand the adductors arise from a median fibrous raphe placed over the middle metacarpal bone. In the foot, adduction is effected towards a line drawn through the index, and the raphe is placed over the metatarsal bone which belongs to this digit (fig. 5, *r.*).

There is no adductor of the index in the *Cuscus*. The fibrous raphe (fig. 5, *r*.) is attached to the outer aspect of the base of its proximal phalanx, and the lower end of this probably represents the missing muscle, which has thus been converted into fibrous tissue.

The adductor hallucis (fig. 5 p^1) is the most powerful of the three muscles of the hallux, and at the same time it is the most complex in its arrangement. It has a double origin—(*a*) from the base of the metatarsal bone of the index, and from the tibial side of the fibrous raphe; (*b*) by a few fibres from the aponeurosis which clothes the dorsal aspect of the first dorsal interosseous muscle. The fleshy fibres soon arrange themselves into three slips which we may distinguish by the terms plantar, intermediate, and dorsal, and by these it is inserted. The plantar slip is attached to the outer of the two sesamoid bones along with the outer head of the flexor brevis hallucis. The intermediate slip ends in a long delicate tendon, and is inserted by this into the fibular side of the minute distal phalanx, and the dorsal portion ends in the extensor tendon.

The adductor minimi digiti (fig. 5, p^5) is a fan-shaped muscle which arises by its base not only from the greater extent of the fibular margin of the fibrous raphe but also from the ligamentous textures at the base of the third and fourth metatarsal bones. From this its fibres converge, and it is inserted into the tibial side of the base of the proximal phalanx of the minimus.

The adductor annularis (fig. 5, p^4) is small in comparison with the preceding muscle, but it has the same triangular shape, and it is placed at right angles to the toe upon which it operates. It arises from the fibular margin of the distal portion of the raphe, and also from the base of the first phalanx of the index. Arching over the base of the medius, it is inserted into the tibial side of the base of the proximal phalanx of the annularis.

The line towards which these muscles adduct the toes is manifestly one drawn through the index, and this, whilst it corresponds with the human foot, is an exception to the general rule that abduction and adduction are effected with reference to a line drawn through the medius.

The intermediate layer (figs. 5, 6, f^1 to f^5).—There are five muscles composing this layer, one to each toe, and they correspond with the same muscles in the preceding animals. Each muscle consists of two slips, and these are inserted one into each sesamoid bone at the base of the digit with which they are associated.

The flexor brevis hallucis (f^1) is one of this group, but owing to the position of the hallux it is somewhat separated from its neighbours. It arises by a single tendinous origin from the under surface of the scaphoid, and dividing into two heads it is inserted by these into the sesamoid bones at the base of the proximal phalanx of the hallux. The tibial insertion is associated with that of the abductor hallucis, and the fibular with that of the plantar part of the adductor hallucis.

The dorsal layer (fig. 6, d^1 to d^6).—This group includes (1) the abductor hallucis;

(2) two divisions of the abductor minimi digiti; (3) the abductor ossis metatarsi minimi digiti; (4) the dorsal interossei.

The abductor hallucis (fig. 5, d^1) is a strong muscle, which arises from the cartilage of the sole, and a sesamoid bone which glides upon the plantar surface of the scaphoid. Its chief insertion is by fleshy fibres into the tibial sesamoid bone of the hallux, but it is also prolonged onwards by a slender tendon to the tibial side of the distal phalanx. By a third slip it gains an insertion into the extensor tendon.

The three abductors of the little toe (fig. 5, d^6 $d^{6'}$ $d^{6''}$) arise side by side from the outer and under surface of the tuber of the os calcis. They are inserted into the base of the metatarsal bone, into the outer sesamoid bone, and into the extensor tendon. The abducting apparatus on the outer aspect of the foot of the *Cuscus*, therefore, is more differentiated than in any of the preceding animals. In the *Thylacine*, a separate slip for the sesamoid is only an occasional occurrence; it is always very feeble, and springs from the base of the metatarsal. In *Dasyurus* it seems to be constant, and it arises further back in the foot. In *Cuscus* it reaches its full development, and arises from the os calcis with its neighbours.

The dorsal interossei are placed more in the sole than the corresponding muscles of the hand. They are not bipenniform, and they show a slight tendency to fuse with the flexores breves.

The first or abductor indicis (fig. 6, d^2) is the most powerful of the series. It arises by two heads—(*a*) from the internal cuneiform (*b*) from the base of the first metatarsal, and it is inserted into the tibial side of the base of the proximal phalanx of the index, and also into the extensor tendon. The index and medius, as we have seen, have no independent power of movement as they are enclosed within the same integumental covering; they constitute, in fact, from a functional point of view, one digit. In consequence of this, the second dorsal interosseous muscle is so completely amalgamated with the inner head of the flexor brevis medii that its presence cannot be detected as an independent muscle.[1] The first dorsal interosseous muscle serves as the abductor of both digits.

The third and fourth dorsal interossei (fig. 6, d^4, $d^{4'}$—d^5, $d^{5'}$) are arranged in a very peculiar and interesting manner. Each consists of two slips. In the case of the third, one of these (d^4) arises from the base of the third metatarsal, and is inserted into the outer aspect of the base of the proximal phalanx of the medius, whilst the other ($d^{4'}$) takes origin on the dorsum of the foot by two delicate heads which spring from the adjacent bases of the third and fourth metatarsal bones. Near the roots of the toes this muscular slip ends in a tendon which bifurcates, and in this manner is inserted into the adjacent sides of the bases of the proximal phalanges of the medius and annularis. The arrangement of the fourth dorsal interosseous muscle is very similar. One slip (d^5) takes

[1] In fig. 6, Plate VI., d^3 represents the deeper part of the inner head of the flexor brevis medii—the portion supposed to represent the second dorsal interosseus—artificially separated and left *in situ*.

origin from the base of the middle metatarsal bone, and crossing obliquely the metatarsal of the annular digit, is inserted into the outer side of the base of the proximal phalanx of this toe. The second slip (d^5) lies in the fourth interosseous space, and springs from the adjacent bases of the two metatarsal bones between which it lies, and, like the corresponding slip of the third dorsal interosseous muscle, ends in a tendon which bifurcates to gain a double insertion into the contiguous sides of the bases of the proximal phalanges of the annularis and minimus.

The third and fourth dorsal interossei, therefore, each consists of two slips, of which one possesses the characteristic insertion of the muscle to which it belongs, and must in consequence be looked upon as an abductor, whilst the other, by its peculiar double insertion, must act as an approximator of the digits into which it is inserted. In the *Cuscus* therefore, there is apparently a tendency to the formation of a fourth layer of muscles, endowed with a new function, by the splitting of the dorsal interossei. In the manus of the *Thylacine* a similar splitting of the dorsal interossei and the development of approximating muscles has already been noted (p. 22).

In the foot of the *Cuscus* an opponens minimi digiti is also to be found (*op.*^{5}). It is a strong quadrate muscle, placed obliquely in the pes, which arises from the outer margin of the plantar cartilage, and is inserted into the whole length of the fibular margin of the metatarsal bone, and also by a few fibres into the outer aspect of the base of the first phalanx of the minimus.

Phalangista vulpina (Australian Opossum).

The foot of this animal in external characters closely resembles that of the *Cuscus*. The hallux is broad, and opposable to the other digits. The medius and index have a common integumental covering, and the annularis is the longest of the four outer toes. Dissection however, reveals certain important points of difference in the arrangement of the intrinsic muscles.

Plantar layer.—The muscles composing this layer were found to differ in their arrangement in the two specimens which were dissected. In one they closely resembled the corresponding muscles in the *Cuscus*. Thus a median raphe extended from the base of the second metatarsal, to the outer side of the base of the proximal phalanx of the index. From this the adductor minimi digiti, the adductor annularis, and the adductor hallucis took origin. The adductor of the ring digit, however, was very feebly developed.

In the second specimen, the raphe stretched from the base of the middle metatarsal to the inner side of the base of the proximal phalanx of the annularis. From this, three muscles arose, either entirely, or in part, viz.:—

1. The adductor minimi digiti.
2. The adductor indicis.
3. The adductor hallucis.

The adductor minimi digiti was very similar to the same muscle in *Cuscus*. It took origin from the whole length of the outer margin of the raphe, and also from the bases of the third and fourth metatarsal bones, and was inserted into the inner side of the base of the proximal phalanx of the little toe.

The adductor indicis arose from the inner margin of the distal two-thirds of the raphe, and converging towards the index was inserted into the outer side of the base of its first phalanx.

The adductor hallucis was a very powerful muscle which arose from the base of the middle metatarsal bone, from the proximal third of the inner margin of the fibrous raphe and from a condensation of the fascia covering the flexor brevis indicis, and which might even be regarded as a second raphe. It was inserted upon the outer aspect of the first phalanx of the hallux, partly into the sesamoid bone, and partly into the extensor tendon.

In the first specimen, therefore, the line towards which the adductor muscles operated was one drawn through the index, as in *Cuscus*, whilst in the second specimen, the annular digit constituted the centre for these movements.

But it becomes a point of interest to inquire into the manner in which the raphe has become attached in the one case to the inner side of the base of the ring digit, and in the other case into the outer side of the index digit. If we refer back to the condition in *Dasyurus*, some light will be thrown upon this. In this animal the adductor minimi digiti and adductor indicis arise from a central raphe which has no distal attachment. From the deep surface of this the adductor annularis takes origin. Now let us suppose this last muscle to be converted into fibrous tissue, and a condition resembling that in the second specimen, the Vulpine *Phalanger*, would result. In place of this, however, say that the adductor indicis degenerates into fibrous tissue, in this case a state of affairs similar to that in *Cuscus* and the first specimen of the Vulpine *Phalanger* would be produced. A careful study of these feet renders it very probable that the fibrous raphe gains its distal attachment in this way.

Intermediate layer.—The flexores breves are well marked, and are five in number—one for each toe. With the exception of that for the little toe which is only represented by a fibular head, each muscle is composed of two slips. The flexor brevis hallucis is more powerful than the corresponding muscle in *Cuscus*. The inner head of the flexor brevis medii apparently contains in its midst the fibres of the second dorsal interosseus which is absent as an independent and separate muscle. Again, the absent inner head of the flexor brevis minimi digiti is in all probability fused with the fourth dorsal interosseus, as this muscle projects more into the sole than any of its neighbours.

Dorsal layer.—This group includes: (1) the abductor hallucis; (2) the abductor minimi digiti and abductor ossis metatarsi minimi digiti; (3) the dorsal interossei.

The abductor hallucis is very poorly developed as compared with the corresponding

muscle in the *Cuscus*, and contains a great number of tendinous fibres in its composition.

The abductors of the little toe are only two in number—one inserted into the base of the fifth metatarsal, and the other partly into the outer sesamoid bone, and partly into the extensor tendon at the base of the minimus.

The dorsal interossei are dorsal in position, and can best be inspected upon the dorsal aspect of the foot. The first or abductor indicis agrees in almost every respect with the corresponding muscle in *Cuscus*. The second, as in *Cuscus*, is apparently absent, but an examination of the inner head of the flexor brevis medii, shows that it has in reality coalesced with it, as this fleshy slip extends upwards between the metatarsals to the dorsum of the foot, so that when viewed from this aspect it seems to be the absent muscle, whilst viewed from the sole, it gives the observer the impression of its being the flexor. The third is a single-headed prismatic muscle, which takes origin from the dorsal surface of the contiguous bases of the third and fourth metatarsals. At the distal extremity of the interosseous space in which it lies, it ends in a tendon which bifurcates to be inserted into the adjacent sides of the bases of the first phalanges of the medius and annularis. Clearly, then, it acts as an approximator of these digits. This muscle therefore corresponds with the same muscle in *Cuscus*, except in its not being supplied with a separate abducting slip for the medius. The fourth dorsal interosseus is a very remarkable muscle. It is not nearly so dorsal in position as the others, still it can readily be seen between the metatarsals from this point of view. It consists of two well-marked fleshy slips. Of these one arises from the plantar aspect of the base of the metatarsal bone of the minimus, and is inserted into the summit (*i.e.*, centre) of an exceedingly powerful tendinous arch which is attached by its extremities to the adjacent sides of the bases of the proximal phalanges of the annularis and minimus. The second slip springs from the plantar surface of the base of the fourth metatarsal bone, and is inserted into the inner end of the tendinous arch (*i.e.*, that extremity which is fixed to the outer aspect of the root of the annularis). This compound muscle therefore resembles the corresponding muscle of *Cuscus*, in so far as it consists of an approximating and an abducting part—the first acting by drawing the minimus and the annularis towards each other, and the second acting by drawing the annularis away from the middle line of the foot.

Dr. Young, in his able paper upon the intrinsic muscles of the Marsupial hand,[1] describes a somewhat similar condition in the manus of the Wallaby. He says :—"The second and third dorsal interossei have a somewhat remarkable arrangement. On their dorsal aspect they closely resemble the corresponding structures in the human hand. They appear as bicipital muscles, springing from the contiguous surfaces of adjoining metacarpal bones; the fibres converge inferiorly to a common insertion, the plane of which is much more palmar in position than is that of the origin. Turning next to

[1] Journal of Anatomy and Physiology, vol. xiv. p. 154.

the palmar aspect of the muscles, two additional bellies are found occupying each of the respective interosseous spaces. These are more or less separable from the bellies seen dorsally, so that four muscular bundles—two dorsal and two palmar—are distinguishable as constituting the third and fourth (second?) dorsal interosseous muscles. All end inferiorly on a common arched tendon, which by its extremities is attached, as in the Opossum, but on a more anterior plane, reaching indeed as far as the sesamoids."

It would appear, therefore, that in certain Marsupial animals, a dorsal interosseous muscle, in addition to the usual mode of insertion, may obtain insertion in three different ways all leading the one out of the other. In the manus of the *Cuscus*, the tendon of insertion of the three outer muscles is fixed by a small transverse band to the head of the metacarpal bone of the digit, which lies adjacent to that into which the muscle is inserted. This acts so as to increase the abducting power of these mucles. In the manus of the *Thylacine* and *Cuscus*, and in the pes of the *Cuscus*, the tendon of certain of the interossei bifurcates, and is inserted into the bases of the contiguous digits. An approximating action is thus gained. Lastly, in the foot of the Vulpine *Phalanger*, and in the manus of certain other Marsupials, a fibrous arch is thrown across between the adjacent bases of two digits, and the muscles are inserted into this.

In the Vulpine *Phalanger*, a very distinct opponens minimi digiti similar in all respects to the same muscle in *Cuscus* is present.

Nerve Supply of the Intrinsic Muscles in the preceding Animals.

In *Thylacinus*, which has no hallux, all the intrinsic muscles are supplied by the external plantar nerve. In the other animals, with the exception of *Cuscus*, the abductor hallucis and the flexor brevis hallucis are supplied by the internal plantar, whilst the remaining muscles draw their nerve supply from the external plantar nerve. In *Cuscus*, however, the abductor hallucis appears to be supplied by a special branch to the hallux (fig. 5).

It is to be noted that in all these specimens, with one exception, the deep division of the external plantar in passing from the outer to the inner margin of the foot lies under cover of the plantar layer of muscles, and superficial to the intermediate and dorsal muscles. The one exception to this arrangement is to be seen, as already pointed out in *Dasyurus*, in which the nerve in turning inwards runs also under cover of the minute abductor of the minimus, which is inserted into the sesamoid bone. Ruge noticed this also in *Dasyurus hallucatus*.[1]

My friend, Dr. Young of Manchester, who has had an opportunity of examining the feet of the Koala and the Virginian Opossum, has very kindly furnished me with the notes

[1] *Loc. cit.*, p. 54.

of his dissections, and also with a plate (Pl. VII.) illustrating these. It is to be understood, therefore, that the following observations upon these two animals proceed from him.

Phascolarctos cinereus (Koala).

The foot of this animal in the undissected state is figured in Plate VII. fig. 1. It possesses five toes, of which the hallux is large, nailless, and placed at right angles to the long axis of the foot, so as to oppose the other digits. The index and medius are shorter and more slender than the other two, and are united by a common covering of skin. The four outer toes are provided with large, curved, very deep and compressed claws.

On the removal of the skin and superficial fascia from the sole of the foot, the deep or plantar fascia is seen to be well marked and arranged in the usual manner. The central portion, however, is prolonged backwards in the form of a cartilaginous tongue-like projection. This affords attachment, chiefly by its base, to most of the short muscles of the hallux and minimus and bridges over the long flexor tendons, as they enter the sole. This cartilaginous plate forms the functional heel. The backward projection of the os calcis is situated at a higher level, and from its under surface a small muscular bundle descends to the upper surface of the plantar cartilage, and acts as an elevator of the heel[1] (Pl. VII. fig. 2, *l*).

The intrinsic muscles of the foot are strongly developed, but whilst the trilaminar disposition is very evident, the dorsal or abducting layer is not complete as regards the typical number of distinct elements.

A study of the attachments and actions of the individual muscles makes it manifest that the middle line of the foot in this animal corresponds with the annularis or fourth toe, and it thus differs from the *Cuscus* and man, in both of which the index or second toe constitutes the centre for the movement of abduction and adduction, and also from the majority of mammals in which the middle line passes along the medius or third toe. It is interesting to note that the hand of the Koala agrees with the foot in this respect.[2]

Plantar layer (Pl. VII. fig. 2).—This group of muscles exhibits many evidences of muscular modifications, which can only be explained by a transference of the middle line of the foot from the medius to the annularis. It is composed of four muscles, viz. :—

1. Adductor hallucis (p^1).
2. Adductor minimi digiti (p^5).
3. Adductor of the medius and index (p^2 and p^3).
4. A slip for the annularis.

[1] This minute muscle is doubtless a differentiation of the subjacent flexor brevis digitorum.

[2] Dr. Young, Intrinsic Muscles of Marsupial Hand, Jour. Anat. and Phys., vol. xiv. p. 158.

These all lie upon the same plane and constitute an exceedingly thin but distinct muscular stratum.

The adductor hallucis arises from the plantar fascia and the ligaments over the bases of the second and third metatarsal bones. Narrowing as it passes downwards and inwards, it is inserted into the outer aspect of the base of the first phalanx of the hallux along with the tibial head of the flexor brevis hallucis.

The adductor minimi digiti is a slender and thin muscle which takes origin from the fibrous structures in relation to the base of the fourth metatarsal bone, and also from a short tendinous intersection which separates it from the muscular slip to the annularis which lies along its inner margin. It is inserted into the tibial side of the base of the first phalanx of the minimus.

The adductor medii et indicis is a broad, quadrate, continuous sheet of muscular fibres placed over the second and third metatarsal bones and the muscles in connection with them. It springs from the proximal two-thirds of a strong tendinous raphe, which stretches from the base of the fourth metatarsal to the base of the first phalanx of the annularis. It likewise derives fibres from the ligaments in relation to the bases of the second and third metatarsal bones. From this wide origin the fibres are directed towards the roots of the middle and inner digits, and as they approach these they diverge slightly so that the inner fibres pass to be inserted into the tibial aspect of the base of the proximal phalanx of the index, whilst the outer fibres go to their insertion into the fibular side of the corresponding phalanx of the medius. At the roots of these toes a few fibres pass transversely, and form a slightly arched bundle which runs directly from one digit to the other.

This muscle is undoubtedly modified in accordance with the syndactyle nature of the digits into which it is inserted, and its actions are in consequence varied.

The fourth muscular slip which belongs to this layer arises from the fibular side of the fibrous raphe, and from a tendinous intersection which separates it from the adductor minimi digiti. It is inserted into the outer side of the first phalanx of the annularis, and must therefore exercise an abducting influence upon this toe. It is difficult to account for the presence of such a distinct abductor in this layer.[1] In all probability, however, it is a portion of the adductor minimi digiti which has shifted its insertion to the adjacent digit. In support of this view we may mention that where there is a median raphe it is the custom for the adductor of the minimus to arise from the greater or indeed the entire extent of its fibular margin (*i.e.*, *Thylacine*, *Dasyurus*, *Cuscus*, Vulpine *Phalanger*), whereas in this case it is shut out from the raphe by the muscular slip in question.

Intermediate layer (figs. 2, 3, f^1 to f^5).—The usual five muscles are found entering into the composition of this layer. With the exception of the flexor brevis minimi digiti each of these muscles consists of two slips.

[1] By referring to Plate II., fig. 3, a somewhat similar slip will be seen in the manus of the *Cuscus* in connection with the index digit.

Flexor brevis hallucis (fig. 3, f^1).—The two bellies of this muscle are separated by the tendon of the flexor longus hallucis. They have a common origin from the thickened part of the plantar cartilage close to the base of the first metatarsal bone. Each belly is joined by the abductor and adductor respectively, and is inserted one into the inner sesamoid bone and the other into the outer sesamoid bone at the base of the first phalanx of the hallux.

The succeeding three flexores breves (fig. 3, f^2 to f^4), viz., for the index, medius, and annularis present the usual arrangement. That for the annular digit, however, is the strongest of the series, seeing that it is in connection with the longest toe. Both bellies of this muscle arise from the base of the third metatarsal bone, and therefore they lie obliquely in the sole. This muscle also differs from the other members of the series in being inserted not only into the sesamoid bones but likewise into the extensor tendon.

The flexor brevis minimi digiti (fig. 3, $f\,5'$) is represented merely by a slender tibial head which arises by a long tendon from the cuboid bone. The fibular head is inseparably united with the opponens minimi digiti.

Dorsal layer (d^1 to d^6 $a.m$).—This layer is represented by only four muscles.

1. The abductor hallucis (d^1).
2. The abductor minimi digiti (d^6).
3. The abductor ossis metatarsi minimi digiti ($a.m$).
4. The abductor indicis or first dorsal interosseus (d^2).

The abductor hallucis arises from the inner margin of the cartilaginous portion of the plantar fascia and is inserted into the tibial side of the first phalanx of the hallux in conjunction with the inner head of the flexor brevis of the same toe.

The abductor minimi digiti takes origin from the inferior surface and outer border of the os calcis. It likewise receives a small separate slip from the plantar cartilage. The fleshy belly of the muscle soon ends in a long tendon which is inserted into the outer side of the proximal extremity of the first phalanx of the minimus. In all probability the small fasciculus which is derived from the plantar cartilage represents the third factor of the abducting apparatus on the outer margin of the foot.

The abductor ossis metatarsi minimi digiti arises from the os calcis in common with the preceding muscle. It has the usual insertion into the base of the fifth metatarsal bone immediately under that of the peroneus brevis.

The abductor indicis consists of fibres which extend between the adjacent margins of the first and second metatarsal bones. It also arises by a long narrow tendon which lies under cover of the flexor brevis hallucis and springs from the tibial side of the base of the metatarsal bone of the hallux. The muscle is inserted mainly into the inner aspect of the base of the first phalanx of the index, but some fibres are likewise inserted into the hallux along with the adductor hallucis.

Macalister[1] describes an opponens hallucis, springing from the internal cuneiform and inserted into the first metatarsal bone, but in six feet examined by Dr. Young no trace of this muscle could be detected. The small tendon of the preceding muscle which takes origin from the inner side of the base of the metatarsal bone of the hallux may exercise a slight opposing action.

An opponens minimi digiti (figs. 2 and 3, *o.m*), however, is always present. It is a thin, but well-developed muscle which springs from the outer margin of the plantar cartilage, and is inserted into the fibular margin of the shaft of the fifth metatarsal bone. The superficial fibres are prolonged to the base of the first phalanx of the minimus, and constitute the only representative of the outer head of the flexor brevis of that digit.

Didelphys virginiana (Virginian Opossum), (Pl. VII. figs. 4 and 5).

The foot of this animal is pentadactylous. The four outer toes are all well-developed, and quite separate the one from the other. The hallux is placed at right angles to the long axis of the foot so as to oppose the other digits, and it is destitute of a nail.[2]

Upon the plantar aspect of the internal cuneiform bone, a well-marked sesamoid bone is situated. From this a tongue-like cartilaginous prolongation proceeds which affords attachment to some of the muscles of the hallux.

In this foot the trilaminar disposition of the intrinsic muscles is very marked. Dr. Young has also shown that in the hand of the same animal the corresponding muscles are arranged upon a similar plan.[3]

Plantar layer (p^1 to p^5).—This group comprises adductors of all the digits with the exception of the medius, which in this case constitutes the centre for the movements of adduction and abduction.

The adductor hallucis (p^1) and the adductor minimi digiti (p^5) are large, flat, triangular muscles. They take origin, by their bases, from a mesial fibrous raphe which extends from the base of the middle metatarsal bone to the base of the proximal phalanx of the medius. The adductor minimi digiti also derives fibres of origin from the ligamentous structures over the proximal ends of the fourth and fifth metatarsal bones. They are inserted by their apices—the one into the outer aspect of the base of the first phalanx of the hallux and the other into the inner side of the base of the proximal phalanx of the minimus.

Together these muscles constitute a continuous muscular sheet of a trapezoidal form, intersected by the fibrous raphe, which extends from the upper to the lower angle. It almost entirely conceals the other muscles of this group.

[1] Muscular Anatomy of the Koala, Annals and Magazine of Natural History, vol. x. (fourth series), 1872, p. 133.

[2] In Waterhouse's work upon Mammalia, a figure of the foot of *Didelphys cancrivora* is given pl. xii. vol. i.

[3] *Loc. cit.*, p.

The adductor indicis (p^2) and adductor annularis (p^4) arise from the deep surface of the greater part of the fibrous raphe under cover of the preceding muscles. They are inserted one into the outer aspect of the base of the proximal phalanx of the index, and the other into the inner side of the corresponding phalanx of the annularis.

In this group of muscles we have another striking illustration of the tendency of the marginal adductors to usurp the middle line by thrusting back the central adductors, and coalescing in the middle line superficial to them. It is a further stage of what we observed in *Dasyurus*, in which the adductors of the hallux, index, and minimus are upon the same plane, and the adductor annularis upon a deeper plane. Here the adductors of the hallux and minimus have come to lie superficial to the adductors of the index and annularis.

Ruge in his article upon the short muscles of the foot[1] figures and describes the muscular and nervous anatomy of the pes of *Didelyphys cancrivora*. In this case the adductor annularis as in *Dasyurus* is the only member of the adducting group which lies under cover of the others. The adductor indicis is a weak muscle which springs from the inner margin of a small portion of the lower end of the median raphe, and therefore lies upon the same plane as the adductors of the hallux and minimus.

Intermediate layer (f^1 to f^5).—Each digit is provided with a flexor brevis, and each of these five muscles is composed of two slips. The two heads of the flexor brevis hallucis are much more strongly developed than those of the other members of this series.

Meckel in the sixth volume of his work upon Comparative Anatomy (p. 466) states that in *Sarigues* (*i.e.* Opossums) the short flexor of the hallux is absent. He adds however, "the adductor is of medium size and divided into two heads which spring very close to each other. . . . They go solely to the base of the first phalanx." Clearly he looks upon the outer head of the flexor brevis as the caput obliquum of the adductor hallucis and the muscle which Dr. Young has named the adductor hallucis as being the caput transversum, or in other words the transversalis pedis. Ruge in his description of the foot of *Didelphys cancrivora* agrees with Meckel, and supports this view by asserting that the muscle in question is supplied by the deep division of the external plantar nerve. He says:—"The muscle for the first toe is already in *Didelphys* separated into two heads. The part arising in common with the fifth contrahens (*i.e.*, adductor minimi digiti) represents the transverse head and the part from the base of the second metatarsal represents the oblique head. Both heads are like the other contrahentes (*i.e.*, adductors) supplied by the external plantar nerve." The presence of the inner head of the flexor brevis hallucis as a muscle distinct from the abductor hallucis is denied by Ruge as well as by Meckel.

[1] *Loc. cit.*, p. 54.

Dorsal layer (d^1 to d^5).—This layer includes—

1. Abductor hallucis (d^1).
2. Abductor minimi digiti (d^5).
3. Abductor ossis metatarsi minimi digiti ($a.m$).
4. Dorsal interossei.

The abductor hallucis (d^1) arises from the sesamoid bone at the base of the first metatarsal bone, and from the adjoining ligaments. It is inserted into the base of the proximal phalanx of the hallux, along with the inner head of the flexor brevis.

The adductor minimi digiti (d^5t and d^5f) arises by two distinct heads. Of these one springs from the outer surface of the os calcis and consists of a fusiform muscular bundle, ending in a long tendon, whilst the other, fleshy throughout, takes origin from the lower border of the annular ligament. Both heads are inserted into the fibular side of the base of the first phalanx of the minimus.

The abductor ossis metatarsi minimi digiti ($a.m$) has a similar disposition to the same muscle in Koala.

Here again, therefore, is another instance of the abducting apparatus on the outer margin of the foot showing a triple arrangement.

The dorsal interossei are four in number. They are single headed muscles, and are inserted so as to act upon the index, medius, and annularis with reference to a line drawn through the middle digit. This toe is therefore provided with two. A slight tendency to fusion between these muscles and the flexores breves is exhibited.

Neither the hallux nor the minimus is provided with an opponens.

Macropus robustus.

The foot of this animal is far from being symmetrical It is tetradactylous, the hallux being completely suppressed. The annularis is enormously developed; the minimus is well marked but not so long as the fourth toe, whilst the index and medius are exceedingly slender, and are enclosed within the same covering of integument. The intrinsic muscles in this foot are deficient both as regards number and development.

Plantar layer.—This layer has only one representative, viz., the adductor minimi digiti, and even this shows signs of regressive change. The proximal two-thirds of this muscle consist of a thin tendinous band, which arises from the fibrous textures upon the plantar surface of the base of the fourth metatarsal bone. The distal third alone is fleshy, and is inserted upon the base of the first phalanx of the minimus, partly into the sesamoid bone, and partly into the extensor tendon. It is distinctly plantar in position.

Intermediate layer.—Each digit has in some form or other a flexor brevis, but that for the annularis is the only one which is well developed. The flexor brevis minimi digiti, like the adductor of the same toe, is fibrous in its proximal two-thirds, and composed of a round tendinous cord which takes origin from the plantar surface of the base of the

fifth metatarsal bone. From the distal end of this, two small fleshy bellies proceed, and these are inserted into the sesamoid bones at the base of the first phalanx of the minimus. A few short oblique fleshy fibres are observed upon the outer surface of the tendinous part of the flexor brevis minimi digiti. These probably represent the abductor minimi digiti.

The flexor brevis annularis is a strongly developed muscle, which lies upon the plantar surface of the fourth metatarsal, and takes origin from the base of the fifth metatarsal bone. Its two heads do not separate from each other until the muscle reaches the metatarso-phalangeal joint. They are then inserted into the sesamoid bones at the base of the annularis.

Two delicate fleshy slips which lie upon the plantar surface of the attenuated metatarsals of the index and medius, and are inserted into the inner sesamoids of these toes, in all probability represent the inner heads of the flexor brevis indicis, and flexor brevis medii respectively.

Dorsal layer.—The members of this group have disappeared. Traces of two, however, are to be found. The abductor minimi digiti is evidently represented by the short fleshy fibres which are found adhering to the outer surface of the fibrous part of the flexor brevis minimi digiti. The fourth dorsal interosseous muscle is present in the form of strong aponeurotic fibres which bind the fourth and fifth metatarsal bones together.

Nervous arrangements.—All the muscles are supplied by the external plantar nerve.

Monotremata.

Ornithorhynchus paradoxus (Duck-mole) (Pl. IX. fig. 5).

The intrinsic muscles in the pes of this animal present a very complicated arrangement, and the following account of their disposition is the result of the dissection of both feet of four specimens. The plantar layer is always quite distinct, but a considerable degree of fusion usually exists between the members of the intermediate and dorsal layers.

Plantar layer.—This group is composed of four muscles, arranged so as to adduct the toes towards the index or second digit. They are—

1. The adductor minimi digiti.
2. The adductor annularis.
3. The adductor medii.
4. The adductor hallucis.

All these have a common origin from the plantar surface of the external and middle cuneiform bones.

The adductor minimi digiti is the largest of the series, and is placed very obliquely in the sole. It is chiefly inserted upon the tibial aspect of the base of the first phalanx of the minimus, but it also sends a slender fleshy process forwards upon the inner aspect of the digit, so as to gain attachment to the second phalanx.

The other three adductors are inserted respectively into the inner sides of the bases of the first phalanges of the annularis and medius, and into the outer side of the base of the first phalanx of the hallux.

In the foot of one very large specimen, I found a delicate muscular fasciculus apparently associated with these muscles and inserted into the outer side of the base of the first phalanx of the medius. I could detect no trace of this minute muscle in the other specimens and it is difficult to account for its presence in this individual case.

In Ruge's excellent paper upon the deep muscles of the sole two additional muscles are described as belonging to this group, viz., one inserted into the inner side of the index digit and another inserted upon the outer side of the minimus. I have looked in vain for the first of these, and the deep division of the external plantar nerve afforded me no help in my search. As Ruge has pointed out, this nerve generally runs across the foot between the adductors and the other intrinsic muscles so as to separate this group from the subjacent flexors and abductors. In the *Ornithorhynchus* I found it impossible to trace this nerve inwards beyond the muscles of the index. It here breaks up into its delicate terminal twigs, in a manner very different from that which is represented by Ruge in fig. 46 of his paper.

With regard to the extra plantar muscle which he describes for the minimus, I have not the least hesitation in pronouncing this to be the outermost belly of the flexor brevis digitorum. I have undertaken three special dissections with the view of determining this point. The flexor brevis digitorum consists of four fleshy bellies. Of these the two for the index and medius arise from the plantar surface of the long flexor tendon as it enters the sole, whilst the other two (viz., those for the annularis and minimus) spring by a common fleshy origin from the under surface of the outwardly directed tuberosity of the os calcis. They are all inserted into the bases of the first phalanges and also partly into the flexor sheathes of the digits to which they go.[1] The identity of the outermost belly is established (1) by its origin being so far apart from that of the plantar muscles, (2) by its continuity at its origin with the fleshy belly of the flexor brevis digitorum for the annular digit, (3) by its lying superficial to the long flexor tendon of the minimus, (4) and lastly, by its having an insertion similar to that of the other bellies of this muscle. It is quite true, as Ruge points out, that it is supplied by a twig from the external plantar nerve, but this of itself is not sufficient to separate it from the muscle to which it so manifestly belongs.[2]

[1] Meckel in his great work upon Comparative Anatomy (*loc. cit.*, vol. vi. p. 447) holds a different opinion regarding these four fleshy bellies. He looks upon them as being the lumbrical muscles. He says : "Le tendon inférieur produit deux muscles lombricaux alongés, qui se rendent à la premiére phalange des deuxième et troisième orteils. Deux muscles sembables, distinés aux troisième (?) et quatrième orteils, sont fournis, non par ce tendon, mais par le bord externe du tarse." The nerve supply certainly seems to favour this view. A reference to page 461 of same volume will show that the second "troisième" in this quotation, should in reality be "cinquième."

[2] In Cuvier and Laurillard's plates (pl. cclxix. fig. 5) the four fleshy bellies are well figured, and they are all included under the name of "court fléchisseur commun."

The dorsal layer.—This layer consists of four dorsal interosseous muscles and an abductor ossis metatarsi minimi digiti.

The abductor ossis metatarsi minimi digiti is a short powerful muscle which takes origin from the outer side of the tuberosity of the os calcis, and is inserted into the fibular aspect of the base of the metatarsal bone of the minimus. This is the only abductor of the minimus, but the outermost belly of the flexor brevis digitorum, from its being inserted upon the outer side of the first phalanx, must in addition to its flexing power possess a very considerable abducting influence, and in this way help to spread out the integumental web which connects the digits.

The dorsal interossei (Pl. IX. fig. 5) have a very complex arrangement, and in order to obtain a proper understanding of them they must be dissected from the dorsal aspect of the foot before the flexores breves are interfered with. The fourth dorsal interosseous (d^5) muscle is single headed and inseparably united with the outer head of the flexor brevis annularis. It arises from the dorsal surface and outer side of the fourth metatarsal bone, and is inserted into the outer side of the extensor tendon of the annularis.

The third dorsal interosseus (d^4) at first sight appears to consist of a single large head which springs from the dorsal aspect of the fourth metatarsal, but on separating the bones between which it is placed a second and much smaller head is discovered lying along its inner side, and taking origin from the outer aspect of the base of the third metatarsal. These slips, but more especially the larger one, are partially fused with the flexores breves of the annularis and medius respectively. Both heads unite near the roots of the toes, and end in a fibrous arch which extends between the contiguous sesamoid bones of the medius and annularis.

The second dorsal interosseus (d^3) is also two-headed, and partially fused with the corresponding slips of the flexores breves of the medius and index. The larger and outer slip springs from the dorsal surface of the third metatarsal near its base, whilst the smaller slip, not so dorsal in position, takes origin from the contiguous bases of the third and second metatarsals. The majority of the fibres are inserted into a fibrous arch thrown across between the adjacent sesamoid bones of the medius and index; the other fibres end in a tendon which passes forward upon the dorsal surface of the arch (with which it is closely united) and finally splits into two delicate slips. These diverge from each other, and are inserted into the extensor tendons on the dorsal aspect of the medius and index. The second and third dorsal interossei, therefore, act as approximators of the index, medius, and annularis. Further, it would appear as if this were the first stage of the process, which was seen completed in the *Cuscus*, where certain of the dorsal interossei are differentiated into approximators and abductors. Here each of the muscles in question consists of two parts, but these have not attained separate insertions. The first dorsal interosseus (d^2) is a small slip which arises from the dorsum and inner surface of the second metatarsal. In most cases it is inseparably fused with the inner head of the

flexor brevis indicis. Lying along the inner side of this muscle is a strong fibrous cord which is attached by its proximal end to the base of the second metatarsal bone. Its distal end splits into two parts which stretch across between the adjacent sesamoids of the index and hallux. The fleshy fibres of the muscle are inserted into the inner sesamoid of the index, through the agency of the outer limb of this fibrous band. The fibrous cord is thus the undoubted representative of the inner head of the first dorsal interosseus, such as is present in the case of the second and third dorsal interossei.

Ruge figures and gives a short description of the dorsal interossei in the *Ornithorhynchus*. He represents them as single-headed muscles, with simple insertions, and so placed as to abduct the toes from a line drawn through the index. I have not seen this arrangement in any of the specimens I have examined.

Intermediate layer.—Whilst there can be no doubt as to the presence of a series of flexores breves, constituting an intermediate layer, the individuality of these muscles is, in a great measure, obscured by their more or less complete fusion with the dorsal interossei. The two heads also of each member of the group show a tendency to coalesce, so that an examination of them, before they have been thoroughly cleaned, gives rise to the impression that each consists of a single fleshy belly, lying upon the metatarsal bone, and inserted into the plantar surface of the base of the proximal phalanx of the digit, with which it is connected. A careful dissection, however, will reveal the fact that they are, as a general rule, two-headed. To effect their separation from the dorsal interossei, it is necessary to reflect the latter muscles from the dorsal aspect of the foot. It is then seen that whilst in some cases the heads of the flexores breves are inseparably united with the dorsal interossei, yet in other cases the union is only partial.

In a young male specimen which I had the opportunity of examining there was little or no fusion between the flexores breves and the dorsal interossei, whereas, on the other hand, the heads of the individual muscles were closely united. This coalescence between the heads of the flexores breves would seem to indicate that the usual two slips of each muscle are derived originally from a single fleshy mass.

Each digit, with the exception of the minimus, is provided with a flexor brevis. These present the usual attachments, but their insertions are more plantar in position. The flexor brevis hallucis is a single bellied muscle which takes origin from the internal cuneiform bone, and is inserted into the inner side of the base of the first phalanx of the hallux. From its taking a more proximal origin than its neighbours, it is probable that it holds in its midst the fibres of the absent abductor hallucis. Indeed Ruge applies this name to the entire muscle. I think, however, that it is better to look upon it as a combination of both.

Plantar nerves.—The plantar nerves have an arrangement in the foot of the *Ornithorhynchus* somewhat different from that generally found throughout Mammalia. The internal plantar nerve alone enters the sole by the hollow of the os calcis, in company with

the tendon of the flexor longus digitorum. In the sole it gives twigs to the flexor brevis digitorum, and then breaks up into cutaneous branches for the digits and web. These supply both sides of the hallux, of the index, and of the medius, and also the tibial side of the annularis. The external plantar nerve reaches the foot by passing over the outer side of the os calcis. Upon the fibular margin of the pes it divides into a minute superficial twig for the outer side of the minimus, and a large deep branch. Before dividing, the nerve trunk gives twigs to the abductor ossis metatarsi minimi digiti, the outermost belly of the flexor brevis digitorum, and the accessorius. The deep division turns inwards under cover of the superficial and deep flexors of the toes, and insinuating itself between the plantar and intermediate muscles divides into a large cutaneous and a small muscular part. The cutaneous nerve emerges at the lower border of the adductor minimi digiti and bifurcates to supply the adjacent sides of the minimus and annularis, whilst the muscular branch continues inwards under cover of the adducting muscles as far as the metatarsal of the index, where it breaks up into its terminal filaments. It supplies all the intrinsic muscles, with the exception of the abductor ossis metatarsi minimi digiti, which receives its nerve direct from the trunk of the external plantar, and the flexor brevis hallucis, which is probably supplied by the internal plantar nerve, although it is right to state that I have been unable to trace any nervous filament to this muscle.

A passage in Meckel's work upon Comparative Anatomy regarding the interossei in the pes of the *Ornithorhynchus* led me also to examine the corresponding muscles in the hand of this animal. He says :—" Dans l'ornithorhynchque, ils se comportent absolument de la même manière que les interosseux de la main ; à cela pres qu'ils sont plus minces et plus grêles." I found the arrangement very different. Thus the plantar layer is only represented by a single minute thread-like muscle—the adductor minimi digiti. The dorsal interossei are also absent, but, in the intermetatarsal spaces, strands of tough fibrous tissue exist, and these may represent them. The intermediate flexores breves are well marked, each being composed of two fleshy slips with the exception of that for the minimus, which has only an inner or ulnar head.

Echidna setosa (Pl. IX. fig. 6).

The foot of the Echidna is pentadactylous, powerful, and somewhat peculiar in its form. The hallux is exceedingly short and stunted, and is provided with a short rounded nail which covers the entire dorsal surface of the digit. The index is considerably longer than the other toes, and is armed with a remarkably long curved claw. The succeeding digits gradually diminish in size as we proceed towards the minimus, and each is furnished with a claw similar in shape to that of the index, but of a size proportionate to that of the digit to which it belongs. The intrinsic muscles of this foot are very weakly developed, and many are absent. The stunted hallux is

provided with rudiments of the three typical muscles which properly belong to this toe. The index also has its complement of muscles, but these are not so distinctly mapped off from each other, as in the case of the hallux. The minimus has an adductor and a flexor brevis, whilst the annularis and medius are only furnished with adductors. But what is particularly noticeable about these muscles is, that they are all (with the exception of the flexor brevis minimi digiti) manifestly undergoing retrograde change. The adductors indeed are so thin that they are semi-transparent.

In the specimen which I dissected, the flexor longus digitorum sent no tendon to the minimus, consequently the outermost belly of the flexor brevis digitorum (*f.d*) is retained for this digit, and is very apt to be mistaken for an intrinsic muscle seeing that the other three bellies are altogether suppressed. This solitary portion of the short flexor of the toes takes origin from the plantar fascia and the tuber of the os calcis, and is inserted into the plantar surface of the base of the second phalanx of the little toe. It is partially fused with the subjacent flexor brevis minimi digiti which obscures its identity still further. St. George Mivart, however,[1] in his well known memoir upon the *Echidna hystrix*, describes a tendon as passing from the long flexor of the toes to the minimus, and denies the presence of any portion of the short flexor.

Adductor or plantar layer (p^1 to p^5).—This layer is well represented, each digit being supplied with one, and the annularis with two. They are inserted so as to draw the digits towards the interval between the index and hallux.

The adductor hallucis (p^1) and adductor indicis (p^2) arise by a common origin from the under surface of the os calcis close to the outer margin of the foot. They cross the sole obliquely, and are placed superficial to the common origin of the other members of this group. The adductor hallucis is a very slender slip which, ending in a minute tendon, is inserted into the outer side of the base of the ungual phalanx of the hallux. The adductor indicis, more strongly marked, ends in a flat aponeurotic tendon which is inserted upon the inner aspect of the second phalanx of the index.

The remaining adductors (p^3, p^4, and p^5) have a common origin from the ligamentous textures upon the under surface of the tarsus, and diverge from each other to reach their respective points of insertion. They are thin bands which end in flat aponeurotic tendons. These are inserted into the tibial sides of the ungual phalanges of the medius, annularis, and minimus respectively. The annularis possesses, however, a very delicate additional fasiculus ($p.\ 4^1$) which seems to belong to this layer seeing that it lies superficial to the deep division of the external plantar nerve, and arises in common with the three outer members of the group. This minute slip is inserted into the plantar aspect of the first phalanx of the annular digit. In all probability it is analogous to the additional

[1] Some Points on the Anatomy of *Echidna hystrix*, by St. George Mivart, F.L.S. (Trans. Linn. Soc., vol. xxv. p. 394).

adducting slip occasionally found in connection with the medius in the foot of the *Ornithorhynchus*. Certainly its presence is equally unaccountable.

Intermediate layer.—Only three muscles of this layer are present, viz.—

1. Flexor brevis hallucis (f^1).
2. Flexor brevis indicis (f^2).
3. Flexor brevis minimi digiti (f^5).

The flexor brevis hallucis although very minute, is yet complete in so far that it possesses two heads. These arise by a common origin from the fibrous structures on the plantar surface of the middle cuneiform bone. Diverging from each other they are inserted into the sides of the second phalanx of the hallux.

The flexor brevis indicis has also two heads, but the tibial head alone is fleshy. It is composed of a collection of very short muscular fibres, which arise from the under surface of the middle cuneiform bone, and are inserted into the inner and plantar aspect of the first phalanx of the index. The fibular head is represented by a short fibrous cord which lies along the outer side of the head.

The flexor brevis minimi digiti is the best developed muscle of the intrinsic group. It is represented by the outer head alone. This springs from the anterior aspect of the projecting tuber of the os calcis and is inserted into the outer side of the second phalanx of the minimus. It is covered by the outermost belly of the flexor brevis digitorum with which it is partially united.

Dorsal layer.—Only two muscles belonging to this group are found, viz.—

1. The abductor hallucis (d^1)
2. The second dorsal interosseus (d^3).

The abductor hallucis, which is very rudimentary, arises from the fascia at root of the hallux and is inserted by a minute thread-like tendon into the tibial aspect of the ungual phalanx of this digit.

The second dorsal interosseus muscle is also very small. It lies in the second intermetatarsal space, but can only be detected from the plantar aspect, of the foot. Tapering towards its distal extremity, it terminates in a tendon which splits into two portions, a very delicate hair-like part for the tibial side of the second phalanx of the medius and a much stronger part for the fibular side of the second phalanx of the index. Whilst therefore the main action of this muscle must be regarded as that of an abductor of the index, opposing in this respect the adductor indicis, it nevertheless possesses through its minute insertion into the medius an approximating influence upon the index and medius.

In the pes of the Echidna there is no clue as to what has become of the absent intrinsic muscles. It is probable that they are lost by suppression. A strange feature

also in connection with this foot is that the stunted hallux, which of all the digits possesses the most limited range of movement, should be the only one to retain its full complement of muscles.

Nervous arrangements.—These present certain characteristic peculiarities. The internal plantar nerve enters the sole by the hollow of the os calcis where it is found lying upon the inner side of the long flexor tendon. It ends by dividing into three digital branches which are distributed as follows, (1) the first runs along the tibial side of the hallux, (2) the second bifurcates to supply the adjacent sides of the hallux and index, (3) and the third divides to supply the contiguous margins of the index and medius. The first or innermost of these digital branches gives a minute twig to supply the abductor and flexor brevis of the hallux. In the leg, long before it reaches the foot, the internal plantar nerve gives off a slender branch which inclines outwards over the flexor longus digitorum, and is then continued upon the outer aspect of the tuber of the os calcis to its distribution upon the fibular border of the foot, and the fibular side of the minimus. It also gives a twig to the solitary belly of the flexor brevis digitorum. This nerve is probably a substitute for the superficial division of the external plantar nerve which is absent in the foot of the Echidna.[1]

The external plantar nerve (*e.p.n.*) also gains the sole, by passing through the hollow of the os calcis. In this situation, however, it lies upon the outer side of the tendon of the flexor longus digitorum and under shelter of the outwardly directed tuberosity of the os calcis. It does not divide into a superficial and a deep branch, but is prolonged downwards as an unbroken trunk upon the accessorius, and under cover of the solitary belly of the flexor brevis digitorum. Suddenly turning inwards, it runs across the sole under cover of the plantar layer of muscles and ends at the tibial margin of the foot in twigs for the adductors of the hallux and index. It gives off (*a*) muscular and (*b*) digital branches.

The muscular branches supply the accessorius and all the intrinsic muscles with the exception of the abductor hallucis and flexor brevis hallucis. The digital branches are two in number. The first proceeds from the nerve trunk before it turns inwards under cover of the plantar muscles, and piercing the adductor minimi digiti divides to supply the adjacent sides of the minimus and annularis. The second digital branch takes origin under cover of the adductor annularis and bifurcates, to supply the contiguous margins of the annularis and medius. This is a peculiar arrangement. The internal plantar nerve gives off a branch which almost invariably springs from the external plantar, viz., the digital branch for the outer side of the minimus, and as it were in return for this, the external plantar gives a nerve which should come from the internal plantar, viz., the digital nerve for the opposed sides of medius and annularis.

[1] Have we not here an explanation of the peculiarity of the nerve-supply of the outermost belly of the flexor brevis digitorum in the *Ornithorhyncus*? In this animal the external plantar takes very much the same course as this branch, and it is probable that it contains, in its midst, the fibres of this nerve.

Carnivora.

Of the Carnivora I have examined the feet of the domestic Dog (*Canis familiaris*), the Dingo (the Australian Wild Dog), the Cat (*Felis catus*), the Puma (*Felis concolor*), the Leopard (*Felis leopardus*), the Lion (*Felis leo*), the Otter (*Lutra vulgaris*), the Badger (*Meles taxus*), the Pole-Cat (*Mustela putorius*), and the Walrus (*Trichechus rosmarus*). In the last four the foot is pentadactylous, whilst in the others it is tetradactylous—the hallux being only represented by a rudimentary metatarsal.

Let us, in the first instance, direct our attention to the tetradactylous Carnivora. In these the metatarsal bones are placed in such close apposition, that the intrinsic muscles of the pes are situated almost entirely upon the plantar aspect of the metatarsus. In the Dog, indeed (Pl. VIII. fig. 4), it is with difficulty that the point of a knife can be introduced into the interosseous spaces. In the Cat, Puma, Leopard (Pl. VIII. fig. 7), and Lion, whilst the bones are in actual contact towards the tarsus, yet they open out towards their phalangeal extremities, and in the narrow eliptical spaces thus formed, the thin, sharp edges of the dorsal interossei may be seen reaching half-way up the interosseous spaces (Pl. VIII. fig. 7, d^3 to d^5).

Owing to this arrangement of the metatarsal bones, the intrinsic muscles are crowded into the sole; further, the clear definition between the three typical layers is in a great measure lost. None of the muscles are suppressed, but fusion has taken place between several which in other feet we have seen as separate and distinct factors. The cause of this fusion, however, cannot be assigned to crowding, because in *Phascogale*, and especially in *Dasyurus*, the condition of the metatarsus is very similar, and yet all the intrinsic muscles have retained their individuality in spite of the limited space they occupy.

Plantar layer.—In all cases the adductor muscles remain as a distinct plantar layer, and they are arranged so as to adduct towards a line drawn through the medius. Generally they are two in number,—viz., (1) the adductor minimi digiti (Pl. VIII. fig. 8, p^5); and adductor indicis (Pl. VIII. fig. 8, p^2). Occasionally a third is to be found in the Dog—an adductor annularis; but this is feebly developed, and always more or less fused with the tibial head of the flexor brevis of that toe. This seems to indicate that in the other animals this muscle is lost by fusion and not by suppression. These adductor muscles, whether two or three in number, all arise by a common origin in the middle line of the foot from the ligamentous textures at the base of the metatarsus, and then diverge from each other to reach their respective points of insertion.

Associated with the plantar layer is the opponens minimi digiti (Pl. VIII. fig. 8, *o.m*). It is a narrow band of fibres which arises in common with the adductor of the little toe, and is inserted into the plantar face of the distal third of the shaft of the fifth metatarsal bone, under cover of the flexor brevis minimi digiti. This muscle was found in all the tetradactylous Carnivora mentioned above.

Dorsal and intermediate layers (Pl. VIII. fig. 8, f^2 to f^5 and d^2 to d^6).—It is in the dorsal and intermediate layers that we find the greatest deviation from our type. The flexores breves (f^2 to f^2), and the dorsal interossei have undergone a partial or complete amalgamation; still there are usually traces left of a character sufficiently patent to enable the dissector to determine the complex character of the muscles with which he has to deal. As a rule, the fusion is complete towards the middle of the metatarsal bone, whilst towards the origin and insertion a partial separation can be effected. But even in cases where no true and natural separation can be made out, a close examination will usually show tendinous intersections running through the muscles, and these afford a clue to their composite character.

The mode of insertion cannot be regarded as giving a sure means by which these fused muscles can be distinguished from each other. The dorsal interossei, it is true, are almost invariably inserted into the extensor tendon; but, on the other hand, the flexores breves are not in all cases inserted into the sesamoid bones alone. One of the two slips is frequently inserted into the extensor tendon as well.

The fused flexores breves and dorsal interossei constitute a series of muscles which are frequently described as bicipital, whilst in reality they are tricipital, and, in the case of the medius, quadricipital.

The dorsal interossei are disposed so as to abduct the toes from a line drawn through the medius. In no case do they arise from the shafts of the metatarsal bones.

It is interesting to note the different dispositions of the abducting apparatus of the little toe in these animals. A tendency is exhibited to its disappearance by fusion with the outer head of the flexor brevis minimi digiti.

In the Leopard it is the most strongly developed. Here we find (1) a well-marked abductor ossis metatarsi minimi digiti (fig. 8, *a.o*), (2) an abductor minimi digiti (d^6), and (3) a small slip which seems to belong to this apparatus. The abductor of the metatarsal bone, and the abductor of the little toe, have a common origin from the proximal and outer aspect of the os calcis. Separating from each other, the former is inserted into the projecting base of the fifth metatarsal bone, whilst the latter is inserted by a long narrow tendon upon the outer face of the base of the first phalanx of the minimus. The small fleshy slip referred to above springs from the base of the fifth metatarsal, at a higher level than the flexor brevis of the little toe, and after a short independent course it fuses with the outer head of that muscle. Is this not the third abductor of the minimus which we have seen present in some of the Marsupials? Against this view, however, is the fact that the tendon of the abductor minimi digiti is inserted both into the sesamoid bone, and into the extensor tendon, on the dorsum of the first phalanx.

In the Puma the arrangement is similar in every respect, except that no trace of the third small supernumerary slip can be detected, and that the slender tendon of the abductor minimi digiti is inserted into the extensor tendon alone.

In the Lion there is a powerful abductor ossis metatarsi and a weak abductor minimi digiti. These are coalesced at their origins for the distance of about an inch. Separating from each other the former attains its usual insertion, whilst the latter is continued onwards as a flat tendon which lies upon and is incorporated with the outer surface of the fibular head of the flexor brevis minimi digiti. Its continuity in this position is quite apparent to the eye. Towards the root of the toe it again becomes separate to join the extensor tendon on the dorsum of the first phalanx of the minimus.

In the Dog not a trace of an abductor of any kind for the little toe is present as a distinct muscle. In one specimen the fibular head of the flexor brevis at its insertion exhibited a slight tendency to split, which might be taken as an indication that this muscle has absorbed by fusion the abductor.

Meles taxus (Badger).

Passing now to the pentadactylous Carnivora, we find that the plantigrade foot of the Badger approaches the typical trilaminar arrangement of intrinsic muscles more nearly than the digitigrade pes of the tetradactylous Carnivora. Still it presents some important deviations.

Plantar layer—This layer is well marked, and the muscles composing it are very readily separated.

They are three in number, viz.—

1. Adductor hallucis. 2. Adductor minimi digiti.
3. Adductor indicis.

These muscles all arise side by side and in one plane from the bases of the second and third metatarsal bones, and then radiate from each other to reach their distal attachments. They are inserted in such a manner as to act as adductors of their respective digits towards a line drawn through the medius. No trace could be found of an adductor annularis or of an opponens minimi digiti.

Intermediate layer.—An undoubted tendency to coalescence between members of this layer and the dorsal layer is exhibited. Certain of the heads of the flexores breves are in consequence lost.

The hallux, the index, and the minimus, are each provided with a double-headed flexor brevis which presents the usual connections. The flexor brevis annularis and the flexor brevis medii are merely represented by single tibial heads. No indication of the lost head of the latter muscle exists, but it is likely that the bulky third dorsal interosseus holds its fibres in its midst. There is no difficulty in tracing the fibular head of the flexor brevis of the ring digit. It is partially united with the fourth dorsal interosseous muscle. At its origin it is quite separate, but very soon the two muscles become completely fused.

Dorsal layer.—This layer like the preceding is not represented by its full complement of muscles. It is composed of—(1) an abductor ossis metatarsi minimi digiti which presents the usual attachments; and (2) four dorsal interossei which are arranged so as to abduct the digits, with reference to a line drawn through the medius. This digit therefore is provided with two members from this group.

The absence of the abductor minimi digiti is readily accounted for by an examination of the outer head of the flexor brevis of this toe. The great bulk of this slip, and the fact that it takes its origin at a more proximal point than its neighbours (from the surface of the long plantar ligament) leads to the conclusion that the lost muscle has coalesced with it. Upon similar grounds also we conclude that the absent abductor hallucis is contained within the inner head of the flexor brevis of the hallux.

Dr. Ruge in his article upon the deep muscles of the sole gives a figure of the adducting muscles in the foot of the *Meles vulgaris*. These agree with the above description, except in so far that they take origin on different planes.

Lutra vulgaris (Otter), (Pl. VIII. fig. 2).

Although the five digits of this foot are contained within a common web of integument, they nevertheless enjoy a wide range of movement, and in consequence the intrinsic muscles are well developed. In their arrangement they show a certain similarity to the same muscles in the Badger, but they approach much more closely the trilaminar disposition. Indeed, with one or two exceptions of minor importance, this foot may be said to meet all the requirements of the typical arrangement.

The plantar or adducting layer (p^1, p^2, p^5) corresponds in the number and character of its elements with that of the Badger. As in the tetradactylous Carnivora, however, an opponens minimi digiti (*o.m*) is developed in connection with the adductor of that toe. This muscle is inserted into the plantar face of the distal third of the fifth metatarsal bone.

The intermediate flexores breves (f^1 to f^5) show only a very slight tendency to fusion with the dorsal interossei. Each digit, with the exception of the hallux, is provided with a double-headed muscle. The flexor brevis hallucis, however, is represented by a single inner head.

The dorsal muscles (d^2 to d^5 and *a.o*) are arranged in a manner similar to those in the foot of the Badger, with the exception that we find a small abductor hallucis present, —quite separate from the inner head of the flexor brevis of that digit.

Mustela putorius (Pole-Cat).

With regard to the pes of the Pole-Cat, my observations do not extend beyond the adducting muscles. The animal was so putrid that a dissection of the deeper layers was impossible. I made out with certainty, however, that the adductors were identical both in point of number and mode of disposition with the corresponding muscles in the Otter and the Badger. Further, like the former, it possesses an opponens minimi digiti developed in the same way.

The plantigrade character of a foot has apparently no effect in regulating the relation which exists between the intrinsic muscles and the metatarsus. In the Badger the plantar position of these muscles is quite as well marked as it is in the Otter and other digitigrade Carnivora.

Trichechus rosmarus (Walrus), (Pl. XI. fig. 3).

The Walrus which I examined was a very young specimen, and one which had been preserved in spirit for a great number of years in the stores of the Edinburgh Anatomical Museum. The muscles, however, were in a remarkably good condition, and I experienced little difficulty in obtaining a satisfactory display of the intrinsic group. Dr. J. Murie in his elaborate series of papers upon the Anatomy of the Pinnipedia, published in the Transactions of the Zoological Society, devotes part 1 (vol. vii.) entirely to the Walrus, and he figures and describes the intrinsic pedal muscles (p. 456). In some points the specimen which I dissected differs from his description.

In the Walrus the intrinsic muscles of the pes are poorly developed, and in no respect proportionate in size to that of the foot. The dorsal and plantar layers are very meagrely represented. The intermediate layer, however, is almost complete as regards its number of elements.

Plantar layer.—The adductor hallucis is the only member of this layer which is present. It consists of two very distinct portions, viz., an adductor obliquus (p^1,*o*) and an adductor transversus (p^1,*t*). Both are narrow flat fleshy bands. The former arises from the plantar surface of the base of the fourth metatarsal bone, and the latter from the fascia covering the flexor brevis minimi digiti close to its insertion. The two heads coalesce upon the plantar aspect of the flexor brevis indicis, and a long narrow tendon emerges from the point of union. By this tendon the muscle is inserted into the extensor tendon upon the fibular aspect of the first phalanx of the hallux.

A slender fibrous band occupies the position of the adductor minimi digiti (p^5). It springs from the base of the fourth metatarsal bone, and is inserted upon the tibial side of the base of the first phalanx of the minimus.

Dr. Murie gives no description of these muscles in the text, but he figures (fig. 8, p. 456) two muscular slips and names them superficial layer of interosseous muscles. One of these has very much the same position as the adductor obliquus hallucis in my specimen, whilst the other occupies the place of the fibrous adductor minimi digiti. He represents both, as arising from the plantar surface of the middle metatarsal. The transverse head of the adductor hallucis is not figured at all.

Intermediate layer (f^1 to f^5).—Each digit is provided with a short flexor which, except in the case of the hallux, is two headed. The flexor brevis hallucis (f^1,f) has only a fibular head; the fibular head of the flexor brevis medii (f^3) is remarkable for its small size; and the two portions of the flexor brevis indicis (f^2) arise at some distance

from each other—the one from the base of the second and the other from the base of the first metatarsal bone. Dr. Murie names these muscles the double (or deep) interossei.

The dorsal layer.—The only elements of this layer which have retained their individuality are—

1. The abductor hallucis (d^1).
2. The abductor ossis metatarsi minimi digiti ($d^{6\prime}$).
3. The abductor minimi digiti (d^6).
4. The third dorsal interosseous muscle (d^4).

The abductor hallucis (d^1) arises from a sesamoid bone which glides upon the tibial side of the internal cuneiform. It is simply a strong rounded tendinous cord with a few muscular fibres at its proximal end, and it is inserted into the inner side of the base of the first phalanx of the hallux. Dr. Murie gives a different description of this muscle. He says:—"The presence of a muscle answering to one of these (*i.e.*, abductor hallucis) in the foot of the Walrus, manifests a commencing change on the adaptation of the pes as an instrument of clutch as well as support. The muscle in question has a long narrow belly, arising by a tendon from the extra bone outside the cuneiform, and is fleshy three-fourths of the length of the hallucial metacarpal (metatarsal ?), being inserted by tendon and fascia into and over the metacarpo-phalangeal joint. Both in the Sea-lion and Seal, tendinous fascia takes the place of this muscle; but it is noteworthy that in *Ursus americanus* its representative is found." The almost completely fibrous condition of the muscle in my specimen associates it with the Seal, and may be accounted for by the youth of the animal.

The abductor ossis metatarsi minimi digiti ($d,6'$) exhibits the usual attachments.

The abductor minimi digiti (d^6) arises from the fascia covering the outer surface of the abductor ossis metatarsi minimi digiti, and is inserted into the outer side of the base of the first phalanx of the minimus.

The third dorsal interosseus is the only member of this group present as a distinct muscle. Not a trace of the remaining three dorsal interossei is to be observed, but as the outer head of the flexor brevis annularis and the inner head of the flexor brevis medii pass for a considerable distance upwards between the metatarsal bones, it is reasonable to suppose that they contain the fibres of the fourth and second members of this group. With regard to the first dorsal interosseus not even this clue, slight as it is, exists, for the inner head of the flexor brevis indicis is plantar in position.

In addition to the above intrinsic muscles two extra fleshy slips are found taking origin from the tarsal bones. The homology of these is somewhat difficult to determine. One ($d^6 \times$) arises from the under surface of the anterior border of the os calcis, and ends in a tendon which is inserted into the fibrous textures upon the plantar surface of the base

of the fifth metatarsal bone. The close association of this muscle, with the abductor ossis metatarsi minimi digiti seems to indicate that it is a development from the latter. Murie, however, points out with truth that if the fibrous structures into which it is inserted be raised (artifically) from the base of the fifth metatarsal, it passes uninterruptedly into the fleshy belly of the outer head of the flexor brevis minimi digiti—the two thus forming a digastric muscle. Upon these grounds he classes it with the short flexor of the minimus.

I am confirmed, however, in my opinion that this muscle is a third abductor of the minimus (which as we have seen is by no means an unusual occurrence) by a study of the corresponding muscle as exhibited in Dr. Murie's drawing of the intrinsic pedal muscles of *Otaria jubata* (Trans. Zool. Soc., vol. vii. pl. lxiii. fig. 38). In this animal the muscle gains an independent insertion into the outer side of the base of the first phalanx of the minimus. Dr. Murie terms it, "flexor brevis minimi digiti." Both heads of the short flexor, however, are likewise present, and these he names the "fifth double interosseus."

The second muscular bundle is very deeply placed, and lies obliquely in the sole (f^1t). It arises from the plantar surface of the middle cuneiform bone and tapering as it proceeds inwards joins the rounded tendon of the abductor hallucis about an inch and half from its origin. This muscle is evidently the inner head of the flexor brevis hallucis, displaced from its neighbour. Dr. Murie's account is somewhat different. He says, "The two short extra and deeply situated muscles met with in the sole of *Otaria jubata* are exactly similar in appearance and situation in *Trichechus rosmarus*. From position and attachments, though covered (and, indeed, entirely hidden), by the deep plantar fascia, they nevertheless may be the homologues of a double adductor hallucis, though it is still more likely that the tibial division is a flexor brevis hallucis, and the fibular one above an adductor." I cannot agree with Dr. Murie, in regarding either of these muscles as the adductor hallucis. The nerve supply shows this, if indeed any other evidence is necessary, beyond the presence of the true and undoubted adductor itself. In my specimen the muscle in question was single and supplied by the internal plantar nerve. Both slips I believe should be associated with the abductor hallucis, and inner head of the flexor brevis hallucis.

Nervous arrangements.—The abductor ossis metatarsi minimi digiti, and the muscular slip associated with it receive their nerve twigs from the trunk of the external plantar nerve (*e.p.n.*). The abductor minimi digiti is supplied by a branch from the superficial division of this nerve (*s.*). The deep division (*d.*) of the external plantar turns inwards under cover of the fibrous adductor minimi digiti and the adductor hallucis, and gives branches to all the intrinsic muscles, with the exception of the flexor brevis and the abductor hallucis. It ends in the substance of the inner head of the flexor brevis indicis. The outer head of the flexor brevis hallucis, the abductor hallucis, and the small deep belly representing the inner head of the flexor brevis hallucis are supplied by twigs

from the digital branch of the internal plantar nerve (*i.p.n.*), which is distributed to the adjacent sides of the index and hallux.

Edentata.

I have examined the feet of three members of this group, viz., the Tamandua, the Armadillo, and the three-toed Sloth. They all deviate from the typical arrangement, and the two last present certain features of great interest.

Myrmecophaga tamandua (Pl. VIII. figs. 5 and 6).

The foot of this animal is pentadactylous; and the toes are all of nearly equal length, and each is armed with a powerful curved claw. The three layers of intrinsic muscles are quite distinct, but there is a considerable reduction in the typical number of elements composing the flexor layer, and abduction and adduction of the digits is not effected with reference to the medius.

Plantar layer (figs. p^1, p^2, p^5).—Three muscles are found in this layer, viz.:—

1. The adductor hallucis (p^1).
2. The adductor indicis (p^2).
3. The adductor minimi digiti (p^5).

The adductor minimi digiti is a narrow muscular slip arising from the base of the fourth metatarsal bone and the sheath of the tendon of the peroneus longus, and inserted into the inner aspect of the base of the proximal phalanx of the minimus.

The adductor hallucis and adductor indicis are fan-shaped muscles, and they take origin in great part from a strong fibrous raphe which is attached by one end to the tibial side of the head and by the other extremity to the tibial side of the base of the fifth metatarsal bone. The adductor hallucis springs by its base from the proximal half of the inner border of this raphe, and also from the ligamentous textures over the bases of the third and fourth metatarsal bones. It is inserted upon the fibular side of the base of the first phalanx of the hallux. The adductor indicis arises from the distal half of the raphe, and has a narrow insertion into the fibular side of the base of the first phalanx of the index.

In the left foot (fig. 5, *p*) an additional adducting slip for the index was found. It took origin from the inner side of the base of the proximal phalanx of the minimus, and stretched transversely across roots of the annularis and medius to reach the index. This points to the tendency which any powerfully developed adducting muscle has to divide into an oblique and a transverse part. It is the result of the same process which is so strikingly seen in the adductor hallucis of Apes and Man.

These adducting muscles in the Tamandua, apparently act so as to approximate the toes towards the annularis. The medius, however, is not provided with a special adductor.

Intermediate layer.—The flexores breves, with the exception of those belonging to the marginal digits, are poorly developed. They can readily be distinguished from the dorsal interossei by their occupying a more plantar plane, and by their being altogether invisible from the dorsal aspect of the foot. The flexor brevis minimi digiti (figs. 5 and 6, f^5f and f^5t) has a powerful fibular head, which takes origin from the under surface of the cuboid, and a delicate tibial head which springs from the base of the fifth metatarsal bone.

The three succeeding short flexors (fig. 6, f^2, f^3, f^4) are one-headed muscles—each consisting of a delicate slip inserted upon the tibial side of the base of the annularis, medius, and index, respectively. In the left foot from which fig. 6 was taken, the flexor brevis annularis (f^4) was two-headed. The flexor brevis hallucis (f^1) is also merely represented by a tibial head, but this is strongly marked, and has a more proximal origin than its neighbours. It springs from the inner side of the ento-cuneiform bone.

Dorsal layer (figs. 5 and 6).—The muscles composing this layer are arranged (as in the case of the human foot) so as to abduct the toes from a line drawn through the index. They are—

1. The abductor hallucis (d^1).
2. The abductor minimi digiti (d^6).
3. The abductor ossis metatarsi minimi digiti (*a.o.*).
4. The dorsal interossei (d^2 to d^5).

The abductor hallucis has a wide origin from a cartilaginous process attached to the inner margin of the sole, and also from the plantar fascia. It is inserted into the inner sesamoid bone at the root of the hallux.

The abductor ossis metatarsi minimi digiti has the usual attachments. The abductor minimi digiti is a narrow muscle arising from the outer side of the tuber of the os calcis, and soon ending in a long slender tendon which is inserted into the outer sesamoid bone at the base of the minimus.

The dorsal interossei (fig. 6, d^2 to d^5) are four in number, one occupying each intermetatarsal space but not reaching forwards to the dorsum of the foot. They are powerful single-headed prismatic muscles, and are inserted so as to abduct the toes with reference to a line drawn through the index. The first and second dorsal interossei are, therefore, appropriated by this digit—one being inserted upon either side of the base of its first phalanx. The third is inserted upon the outer side of the base of the proximal phalanx of the medius, and the fourth upon the outer side of the base of the corresponding phalanx of the annularis.

There is, therefore, a very apparent want of correspondence in the arrangement of the adductors and abductors in Tamandua—the former acting towards the annularis, and the

latter towards the index. The flexores breves of the medius and annularis which are merely represented by tibial heads act no doubt like the first and second plantar interossei in man by antagonising the action of the third and fourth dorsal interossei. The index presents the anomaly of being provided with four intrinsic muscles, viz., (1) an adductor, (2) the tibial head of a flexor brevis (antagonistic to the adductor), and (3) two dorsal interossei (antagonistic to each other). So far as I am aware, this disposition of muscles is quite unique.

In Cuvier and Laurillard's plates[1] the abductor and the flexor brevis hallucis are alone figured (pl. cclxiii. fig. 1).

Rapp[2] merely describes the abductor minimi digiti, and states that the interossei lie in the intervals between the toes.

From a careful study of the account given by Professor Humphry[3] of the intrinsic muscles in the foot of the Manis (*Manis dalmani*), it seems to me that in their arrangement they closely resemble those of the Tamandua. Thus the plantar layer is composed of—(1) an adductor hallucis, (2) an adductor minimi digiti, (3) an adductor indicis, and (4) a transversus indicis, all of which are inserted in a similar manner to the corresponding muscles in Tamandua. These muscles Professor Humphry terms plantar interossei, and he classes with them two additional muscles, which he remarks are "situated on rather a deeper plane, nearer to the metatarsals, and pass, one to the fibular side of digit 3, and one to the fibular side of digit 4." These latter appear to me to be the fibular heads of the flexor brevis medii and flexor brevis annularis. With regard to the intermediate flexores breves it is evident that he includes three members of this group amongst the dorsal interossei, viz., the tibial head of the flexor brevis medii, the tibial head of the flexor brevis annularis, and the tibial head of the flexor brevis minimi digiti. This layer therefore, consists of—(1) a tibial head of the flexor brevis hallucis, (2) a two-headed flexor brevis medii, (3) a two-headed flexor brevis annularis, and (4) a two-headed flexor brevis minimi digiti. The dorsal layer thus reduced will consist of the same component parts as the corresponding layer in Tamandua, with the exception of the abductor ossis metatarsi minimi digiti, which is absent in Manis. Further, these muscles are inserted so as to abduct from a line drawn through the index.

The only essential difference between the intrinsic muscles in the foot of the Tamandua and of the Manis would appear to be in the disposition of the flexores breves. In the former each digit is supplied with a short flexor, but in the case of the minimus alone is this muscle two-headed; in the Manis the index has no flexor brevis, and the flexor brevis medii, the flexor brevis minimi digiti, and flexor brevis annularis are two-headed.

[1] Anatomie Comparée Recueil de Planches de Myologie.

[2] Anatomische Untersuchungen über die Edentata.

[3] The Myology of the Limbs of the Unau, the Aï, the two-toed Ant-eater, and the Pangolin, Jour. Anat. and Phys., vol. iv.

The intrinsic muscles of the foot in Tamandua derive their nerve supply in the usual manner, viz., the abductor hallucis and flexor brevis hallucis from the internal plantar nerve, and the other muscles from the external plantar nerve. The deep division of the external plantar nerve traverses the sole, between the plantar and intermediate layers of muscles (fig. 5, *e.p.n.*).

Dasypus sexcinctus (Pl. VIII. fig. 3).

The foot of this animal is of peculiar interest from the fact that, except in the case of the hallux and minimus, the intermediate flexors and the dorsal abductors have undergone regression, and are converted into fibrous tissue.

The plantar layer is well represented. It consists of four muscles, viz. :—

1. The adductor hallucis (p^1).
2. The adductor indicis (p^2).
3. The adductor annularis (p^4).
4. The adductor minimi digiti (p^5).

These are inserted so as to adduct the toes towards a line drawn through the medius. The first three arise by a common origin from the fibrous textures at the bases of the second and third metatarsal bones, and from this they diverge so as to reach their respective insertions. The adductor indicis has an additional head of origin from the base of the third metatarsal in common with the origin of the adductor annularis. This may represent a transversus indicis.

Intermediate layer.—Only two members of the intermediate group are present, viz., the flexor brevis hallucis (f^1f and t), and the flexor brevis minimi digiti (f^5).

The flexor brevis hallucis is well developed, and has the usual bicipital character. The tibial head (f^1t) is, however, to a certain extent fused with the abductor hallucis (d^1), and takes origin by a common tendon with this muscle, far back in the sole, from the ligaments in connection with the os calcis and astragalus. The outer or fibular head springs from the plantar surface of the ento-cuneiform, and both slips are inserted into the sesamoid bones at the base of the hallux.

The flexor brevis minimi digiti (f^5) is an exceedingly minute slip of muscular fibres, and can have little or no action upon the digit into which it is inserted.

The dorsal layer is composed of three muscles, viz., the abductor hallucis (d), the abductor minimi digiti (d), and the abductor ossis metatarsi minimi digiti (*o.m.*).

The abductor hallucis, as we have seen, to a certain extent fuses with the tibial head of the flexor brevis, and they both have a common origin from the astragalus and os calcis. They soon separate, however, and the abductor is inserted by a long narrow tendon into the tibial side of the ungual phalanx of the hallux.

The abductor minimi digiti and abductor ossis metatarsi arise from the os calcis. The

former is inserted by a long tendon into the fibular side of the distal phalanx of the minimus, whilst the latter is inserted into the base of the metatarsal bone of the same digit.

But the most remarkable feature in the pes of the *Dasypus sexcinctus* is that the place of the absent muscles is taken by fibrous bands (*f.b.*) which have precisely the same disposition and connections as those muscles of which they are the substitutes. These fibrous bands represent the fused flexores breves and dorsal interossei, and it is difficult to ascribe to them any function unless they act by preventing over-extension at the metatarso-phalangeal joints. The outer head of the flexor brevis indicis is not entirely transformed into fibrous tissue. Lying along its deep margin a fleshy slip of considerable size may be detected. From the manner in which the digits are bound together, they can have little power of independent movement, and this, no doubt, is the reason of the transformation of these intrinsic muscles into fibrous bands.

A very accurate account of the myology of the pes of this animal may be found in an able memoir by Mr. J. C. Galton.[1] I cannot agree with Mr. Galton, however, in the terms which he has applied to certain of the muscles. He looks upon the muscle which stretches between the os calcis and the base of the fifth metatarsal bone as being the abductor minimi digiti, and the muscle passing from the os calcis to the ungual phalanx of the minimus as being the flexor brevis. There can be little doubt that these muscles represent those after which I have named them, viz., the abductor ossis metatarsi and the abductor minimi digiti. The minute fasciculus (to which, by the way, he has affixed no name) appears to me to be the true flexor brevis minimi digiti.

But, again, he is of opinion that the adductor minimi digiti is the opponens. Such a conclusion I consider to be altogether untenable, as it is the very essence of an opponens that it should be inserted into the metatarsal bone, whilst this muscle is inserted into the distal phalanx.

The only discrepancies which exist between the above description of the intrinsic muscles in the foot of *Dasypus* and that given by Mr. Galton are: (1) he takes no notice of the fibular head of the flexor brevis hallucis which was very apparent in my specimen; and (2) he mentions an "interosseous" muscle going to the tibial side of the root of the index. This muscle was only present in the form of a fibrous band in the Armadillo I dissected, and it apparently represents the first dorsal interosseous muscle fused with the tibial head of the flexor brevis indicis.

Professor Macalister[2] mentions two muscles in *Dasypus* which in my specimen were merely represented by fibrous bands, viz., an abductor indicis or first dorsal interosseous muscle, and an abductor annularis or fourth dorsal interosseous muscle. It is a point of

[1] Linnean Transactions, vol. xxvi. pp. 562 and 563.

[2] Anatomy of *Chlamydophorus truncatus*, with notes on the structure of other species of Edentata, Transactions of the Royal Irish Academy, vol. xxv. p. 253.

great interest therefore to find that the transformed muscles in some cases assume their original condition. So far as I am aware no author has hitherto noticed these ligamentous bands in the foot of the Armadillo.

It is very unfortunate that Dr. Murie,[1] in his memoir upon the three-banded Armadillo, owing to a mishap which befell the feet, was able to give so little information upon the intrinsic muscles. He merely states that he was able to make out "strong interossei and other flexores breves. They were fewer in number than those specified by Galton in *Dasypus*."

In Cuvier and Laurillard's plates of the six-banded Armadillo the intrinsic muscles of the foot are not figured.

In the highly interesting memoir upon the limbs of the *Orycteropus capensis* by Mr. J. C. Galton[2] a series of fibrous bands are described in the foot which apparently represent missing elements of the intrinsic group of muscles. He describes each as being "a strong ligament which passes, forked at both extremities into a resemblance to an X, from the plantar aspect of the base of the metatarsal to the sesamoids, at the base of the proximal phalanx of each digit." They are confined to the three middle digits, and a reference to the beautiful figure (pl. xlvi. fig. 3) which accompanies this memoir, renders it apparent that they are transformed flexores breves. A fleshy short flexor for each of the remaining digits (viz., the minimus and hallux) is also present. Fibrous bands of a somewhat similar nature are likewise found in the manus of the same animal, and Mr. Galton calls them the "metacarpal ligaments."

Professor Humphry[3] in his paper upon the myology of the same animal makes no mention of these ligamentous slips.

Bradypus tridactylus (Pl. IX. figs. 2, 3, 4).

The remarkable hook-like character of the pes of the three-toed Sloth naturally suggests a corresponding peculiarity in the arrangement of the intrinsic pedal muscles. This we find to be the case. In this foot the index, medius, and annularis are alone fully developed. These are pressed tightly together, and enveloped by a common integumental covering, which reaches as far forward as the bases of the enormous claws. The digits possess therefore almost no power of independent movement. Further, the proximal phalanges of these toes are shortened to such an extent that they are merely represented by three square osseous nodules of little more than a quarter of an inch in length, which at an early age coalesce with the heads of the metatarsals, so as to render any movement at the metatarso-phalangeal joints impossible. The metatarsus is flanked on each side by a rudimentary metatarsal bone which supports no phalanges. These are rudiments of the hallux and minimus.

[1] The Three-banded Armadillo, Trans. Linnean Society, vol. xxx.

[2] The Myology of the Upper and Lower Extremities of *Orycteropus capensis*, Linnean Transactions, vol. xxvi. p. 567.

[3] On the Myology of *Orycteropus capensis* and *Phoca communis*, Jour. Anat. and Phys., vol. ii. pp. 305 and 317.

The primary office of intrinsic pedal muscles is to act upon the digits at the metatarso-phalangeal joints. In the Sloth, owing to the ankylosis of the first phalanges to the metatarsal bones, this function is abolished. Consequently, in the dissection of the sole not a vestige of an intrinsic muscle is to be found. The dorsal interossei, however, from their very common connection with the extensor tendons on the dorsal aspects of the digits, act secondarily (as Duchenne has pointed out) as extensors of the toes at the joints between the phalanges. In the Sloth these muscles are therefore retained upon the merits of this action. They have no action as abductors; they merely constitute accessory parts of the weak extensor apparatus on the dorsum of the foot, and must be studied in connection with the extensor brevis digitorum.

The extensor brevis digitorum (fig. 2, *fl br.d*) arises by two heads—one from the outer surface of the astragalus and os calcis, and the other from the dorsal aspect of the cuboid. These unite to form a flat ribbon-like muscle which ends in two tendons for the ungual phalanges of the index and medius respectively.

The dorsal interossei (fig. 2, d^2, d^3, d^4, d^5) are four in number, and constitute the only intrinsic muscles in this foot. The second (d^3) and third (d^4) are the most strongly developed, and they lie in the second and third inter-digital spaces. There they arise not only from the adjacent surfaces of the metatarsal bones but also from the sides of the proximal phalanges. The second, moreover, passes backwards for a considerable distance upon the dorsum of the tarsus. They both extend forwards as fleshy masses to the bases of the ungual phalanges, and here each divides into two portions. Two of these portions (viz., one from each muscle) are inserted into the dorsal aspect of the base of the third phalanx of the medius under cover of, and closely connected with, the tendon of the extensor brevis to this digit. An expansion is thus formed over the second phalangeal joint, which is fleshy at the margins where it is composed of fibres derived from the second and third dorsal interossei and tendinous in the centre where it is formed by the tendon of the extensor brevis. The inner part of the second dorsal interosseus is inserted in like manner, with the corresponding tendon of the extensor brevis into the dorsal aspect of the base of the ungual phalanx of the index. In this case, however, the expansion formed is fleshy only at its outer margin, and tendinous along its inner margin. The outer portion of the third dorsal interosseus is inserted in a similar manner into the ungual phalanx of the annularis. It is joined by the tendon of the fourth dorsal interosseous muscle.

The first dorsal interosseous muscle (d^2) is poorly developed in comparison with the preceding. It springs from the inner aspect of the rudimentary first metatarsal, and also from the dorsal surface of the base of the second metatarsal bone. It soon ends in a long narrow tendon which runs along the inner margin of the foot, to join the tendon of the extensor brevis for the index at the point where it merges into the dorsal expansion.

The fourth dorsal interosseous muscle (d^5) is also small. It takes origin in the interval between the rudimentary fifth and the fourth metatarsal bones, and almost immediately ends in a slender tendon which is inserted into the expansion formed by the outer part of the third dorsal interosseous muscle on the dorsum of the second phalangeal joint of the annularis.

But it may be asked, What has become of the other members of the intrinsic group of muscles? I believe that the adductors, and the marginal abductors are suppressed whilst the flexores breves have wandered to the dorsum of the foot and coalesced with the dorsal interossei. I have come to this conclusion, from an examination of the corresponding muscles in the manus of the same animal, and as the arrangement found in this is even more remarkable than that in the foot, I am induced to give a description of it (Pl. IX. figs. 3 and 4).

In general features the manus of the three-toed Sloth is very similar to the pes. The metacarpus and the phalanges resemble in almost every respect the corresponding bones of the foot. The intrinsic muscles, however, are not banished from the palm. There is a distinct palmar layer of adductors; rudiments also of the flexores breves are to be found.

Palmar layer (fig. 3, p^2 p^{2x} p^4).—This layer is composed of two muscles, viz., (1) the adductor annularis (p^4), and (2) the adductor indicis. These muscles are flat ribbon-shaped bands which cross each other in the palm like the limbs of the letter X.

The adductor annularis is the more superficial of the two. It arises from the bases of the first and second metacarpal bones, and extends obliquely across the palm to the inner margin of the hand, where it is inserted partly into the palmar face of the stunted first phalanx, and partly into the head of the metacarpal bone of the annular digit.

The adductor indicis is composed of an oblique ($p.\,2\times$) and transverse part ($p.\,2$). The former takes origin from the base of the fourth metacarpal bone, and extending obliquely towards the root of the index is inserted into the radial and palmar aspect of the first phalanx, and also into the head of the metacarpal bone of this digit. The transverse adductor is a small slip which springs from the palmar surface of the middle metacarpal bone, near its head, and stretches transversely from this towards the index where it joins the oblique adductor close to its insertion.[1]

As the digits have no more power of independent movement these adductors can have little or no action beyond bracing together the margins of the manus. That they are undergoing retrograde development is rendered likely from the fact that they are largely composed of tendinous fibres. It is probable, therefore, that these muscles in

[1] Although I have described these palmar muscles as adductors of the index and annularis from their insertions into these digits, I am rather of opinion that they represent the adductors of the absent hallux and minimus. This view would account for their palmar insertions.

the foot have disappeared by suppression, and that the adductors of the hand are following their example.

The *dorsal layer* (fig. 4, d^2 to d^5) is represented by four dorsal interossei. These are arranged in a manner almost identical with that of the same muscles of the foot with the exception that the tendons of the common extensor replace those of the extensor brevis in the formation of the two radial expansions on the dorsal aspect of the second phalangeal joints, and that the second dorsal interosseus muscle does not extend upwards upon the carpus, but is confined entirely to the second inter-digital interval.

In both hand and foot the proper extensor apparatus of the digits is exceedingly weak. In the former there are only two small tendons sent by the extensor communis, to the medius and index, and in the latter two equally small tendons are given by the extensor brevis to the same digits. The dorsal interossei however make up for this deficiency. The annular digit is entirely dependent upon this group of muscles for the production of this movement.

Intermediate layer (fig. 4 f^2 to f^5).—Under cover of the adductors we find five small muscles which without doubt represent the flexores breves. In this case, however, they possess no flexing action upon the digits, but are rather converted into extensors by being carried backwards through the interosseous spaces to join the dorsal interossei.

The flexor brevis pollicis consists of two very minute thread-like fasciculi which spring from the plantar aspect of the base of the rudimentary first metacarpal bone. They sink into the substance of the fibrous cord which prolongs this bone forwards, and in this way they gain an insertion into the radial aspect of the first phalanx of the index.

A small slip (f^3 r), evidently the radial head of the flexor brevis indicis, takes origin from the outer side of the base of the index metacarpal, and at once turns backwards through the first interosseous space to join the first dorsal interosseous muscle. The ulnar head of the same muscle (f^3u) arises from the inner side of the base of the same metacarpal, and inclines backwards in the second interosseous space, to join the second dorsal interosseous muscle. This slip is so closely connected with the interosseous muscle that at first sight it appears to be merely a part of it.

The short flexor of the medius has disappeared altogether.

The flexor brevis annularis (f^4) arises by two well-marked heads of which one springs from the outer side of the base of the fourth metacarpal bone, whilst the other, considerably longer, takes origin from the unciform bone. These soon unite, and the muscle is then directed through the third interosseous space to join the third dorsal interosseous muscle.

The flexor brevis minimi digiti (f^5) is a small fleshy belly which arises from the base of the rudimentary fifth metacarpal bone, and then passes backwards between it and the fourth metacarpal to effect a junction with the fourth dorsal interosseous muscle.

So far as could be made out all the intrinsic muscles of the hand were supplied by the deep division of the ulnar nerve (fig. 3, *d.u.n*). This passed outwards in the palm under cover of the adductor muscles.

The literature bearing upon the intrinsic muscles of the pes and manus of the *Bradypus tridactylus* is very plentiful, but somewhat conflicting.

Professor Macalister[1] in his paper upon the myology of this animal says:—"The short muscles of the hand are—abductor primi digiti, a short flat band passing from the scaphoid bone, and the annular ligament to the first phalanx of the inner digit; on raising this and the flexor tendons, I could see no traces whatever of palmar interossei. Extensor brevis digitorum manus, a small muscle on the back of the hand, which seems to contain the displaced germs of the dorsal interossei; its tendon joins the aponeurosis of the extensor digitorum longus, and is inserted along with it." From its connections it would seem that this abductor primi digiti is the muscle which I have named, the adductor annularis. Further, I believe that the extensor brevis manus is in reality the dorsal interossei.

Macintosh[2] gives the following account of the intrinsic muscles of the manus:—"Abductor annularis is bicipital, one head from the base of the germ of the inner metacarpal, and the other from the pisiform. Adductor annularis extends from the outer side of the carpus obliquely inwards to the distal end of the fourth metacarpal. . . . Adductor pollicis arises from the ulnar side of the base of the combined metacarpal, and is inserted into the base of the rudimentary thumb. The first and second palmar interossei, normal in our specimen and in Professor Humphry's, were absent in Professor Macalister's." Speaking of the foot he says:—"The muscles of the digits are abductor and adductor indicis and medii, all more or less fused; abductor annularis from rudimentary fifth metatarsal to the extensor tendon of the outer digit; adductor annularis from the fourth metatarsal to the same digit. The two plantar interossei send in two slips on the plantar aspect of the foot."

This description is somewhat difficult to follow. It appears, however, that whilst the dorsal interossei never alter in their arrangement, the vestiges of the flexores breves and adductors are subject to considerable variation. Thus they may be absent in the hand, as in Professor Macalister's specimen; present in both hand and foot as in Mr. Macintosh's specimen; or present in the hand and absent in the foot, as in my specimen.

In Professor Humphry's[3] account of these muscles which, in so far as the dorsal interossei are concerned, agrees in almost every respect with that which I have given, there is no mention of plantar or palmar muscles as distinct elements, but the author speaks of

[1] On the Myology of the *Bradypus tridactylus*, with Remarks upon the General Muscular Anatomy of the Edentata, Annals and Magazine of Natural History, vol. iv. p. 62.

[2] On the Myology of the Genus *Bradypus*, Proc. Roy. Irish Acad., vol. i. p. 524.

[3] Myology of the Limbs of the Unau, the Aï, the two-toed Ant-eater, and the Pangolin, Jour. Anat. and Phys., vol. iv.

the interossei as extending between the bones into the sole and into the palm. He appears to have had a very just conception as to the homology of these muscle extensions. In page 50 of his article he refers to them as flexores breves. He makes no mention of the adductors which were so apparent in the manus of the animal I dissected.

Cuvier and Laurillard figure the dorsal interossei in both the hand and foot of the three-toed Sloth (pl. cclii. fig. 1).

Ungulata.

The feet of the Horse, Ox, Sheep, Camel, and Pig are of great interest on account of the modifications which the intrinsic muscles have undergone to suit the requirements of the limb. In the first three of these animals the different steps by which the process has been brought about can be traced with great exactness.

Equus caballus (Horse), (Pl. IX. fig. 7, and Pl. XI. figs. 7 and 7*a*).

In the foot of the Horse, the middle digit is alone developed. It consists of a powerful metatarsal, succeeded by three phalanges. Rudiments of the second and third metatarsal bones are also present, but these do not extend so far down as the metatarso-phalangeal or fetlock joint, and they support no phalanges. Now this single digit of the horse is supplied with the three typical intrinsic muscles which usually belong to the medius or middle toe, viz.: the flexor brevis medii and the second and third dorsal interosseous muscles.

The flexor brevis medii (Pl. IX. fig. 7, f^3) is converted into fibrous tissue, and forms an exceedingly powerful ligamentous structure (nearly twice as thick as the tendo achillis of man) which is termed by veterinary anatomists the "suspensory ligament of the fetlock" or "ligamentum volare rectum ossium sesamoideorum superius." It lies upon the posterior surface of the large middle metatarsal bone, and is attached by its upper end to the plantar aspect of the base of this bone, and also to the lower tarsal bones. Inferiorly, it divides into two portions which, diverging from each other, embrace the metatarso-phalangeal or fetlock joint, and are inserted partly into the sesamoid bones on the plantar aspect of the base of the first phalanx and partly into the extensor tendon on the dorsal aspect of the same phalanx.

The transformation of this ligament into fibrous tissue, enables it to play a most important part in the mechanism of the limb. It prevents over extension at the fetlock joint, and its value in this respect is evidenced by the fact that in cases where it is ruptured, the animal becomes what, in veterinary language, is termed "broken down," *i.e.*, the fetlock joint sinks down and the hoof has a tendency to tilt forwards and upwards.

The most interesting point, however, in connection with this structure, is that it bears its history on its face. Almost invariably two thin streaks of striated muscular fibres are to be found on its superficial surface, leading down to its two inferior divisions.

Again, on examining its deep surface, two very distinct strands of pink fleshy tissue are always observed extending throughout the entire length of the ligament. These consist in each case of short oblique striated fibres, converging towards the middle line of the ligament. They represent those muscular fibres of the two heads of the flexor brevis which have not yet been converted into fibrous tissue.

On making a thin microscopic transverse section of the suspensory ligament, the muscular fibres are seen to sink deeply into its substance. Placing such a section against a black ground, and examining it with the naked eye, two very distinct crescentic outlines of transversely divided muscular fibres are observed embedded in the general mass of tendinous tissue (Pl. XI. fig. 7). Subjecting now the specimen to the microscopic test, we find that the outlines of muscular fibres are broken at intervals by quantities of fat cells, and amidst these we can detect, every here and there, transversely divided nerves and blood-vessels (Pl. XI. fig. 7, *a*). These crescentic outlines of a tissue so foreign to the intimate structure of a true ligament undoubtedly represent the remains of the two heads of the muscle from which the ligament is derived.

The muscular tissue is so small in amount in comparison with the bulk of the ligament that it can exercise no function whatever. To account for its existence, we must of course suppose that it receives twigs from the nerves which traverse the structure, and further, that it contracts; but it would be absurd to imagine that the contraction could be followed by any appreciable result.

Veterinary anatomists are quite familiar with the presence of these fleshy fibres. Gamgee and Law[1] state that the suspensory ligament has in most cases a few muscular fibres. Chauveaux[2] remarks that it often contains "fasciculi of fleshy fibres in its texture." Perhaps of all books on veterinary anatomy, Percival, in his work upon the Horse, gives the best account of the relation of these muscular fibres to the ligament. To quote his words:—"In composition and texture, this ligament possesses peculiarities, it has a sanguineous tinge interiorly, which is not perceptible in other ligaments or tendons, and its fibres, which are very coarse, are disposed in layers. But its chief peculiarity consists in its exhibiting an intertexture of delicate, pinky, fleshy fibres which seem to be the uniting medium of the ligamentous fasciculi."[3]

All are likewise agreed as to muscular derivation of the ligament, although there is considerable difference of opinion as to the actual muscles which have entered into its composition. George Stubbs,[4] writing so far as back as 1766, applies the term "interosseus" to the suspensory ligament, but considers it the representative of no less than five muscles. To use his own words, "it is of a ligamentous nature, but it supplies the places of the interosseus, the short flexor, adductor, and abductor of the great toe, the

[1] General and Descriptive Anatomy of the Domestic Animals, p. 277.
[2] Comparative Anatomy (translated by Fleming), p. 157.
[3] Anatomy of the Horse, p. 74.
[4] Anatomy of the Horse, Explanation to plate. xv.

abductor and short flexor proper to the little toe, and a ligament which arises from the calcaneum." Chauveaux [1] states that it corresponds to the two muscles, which in man, lie along side the interosseous metacarpal muscles. I am at a loss to understand the two muscles to which he refers. Gamgee and Law [2] are also somewhat vague. They remark that the interosseous muscle of the medius is "transformed into the suspensory ligament." Meckel in his "Traite Général d'Anatomie Comparée" (p. 443), asserts that this ligament is not only the representative of the interossei, but also of the lumbrical muscles. Two minute lumbricals, however, are present as independent muscles in the foot of the horse.[3] Professor W. H. Flower, in his recent article upon the "Zoology and Anatomy of the Horse," in the ninth edition of the Encyclopædia Britannica, vol. xii. p. 178, says:—"Its attachments and relations, as well as the occasional presence of muscular fibres in its substance, show that it is the homologue of the interosseous muscles of other mammals, curiously modified, both in structure and function to suit the requirements of the horse's foot."

The second (Pl. IX. fig. 7, d^3) and third dorsal interossei (Pl. IX. 7, d^4) are very rudimentary, and are placed one upon each side of the flexor brevis or suspensory ligament. Each muscle consists of a small fleshy belly, about two inches in length, succeeded by a long narrow delicate tendon. The second dorsal interosseus arises from the outer side of the base of the small second metatarsal bone, whilst the third springs from the inner side of the base of the rudimentary fourth metatarsal and each is inserted upon its own side of the fetlock joint, where it joins the band sent by the suspensory ligament to the extensor tendon on the dorsum of the first phalanx.

The dorsal interossei of the Horse, from their minute size, can exercise no abducting action upon the medius. They are merely vestiges, and point to retrograde development. Rigot considers that they have "the power of raising the synovial membranes of the pastern joint and sesamoid sheath during flexion" (*vide* Gamgee and Law, p. 413). A close study of their connections renders such an action very improbable.

The chief interest of these rudimentary interossei muscles centres in the fact that they constitute a link in the soft parts between the Horse of the present day, and its three-toed ancestor. They are undoubtedly vestiges of well developed interosseous muscles which lay in the second and third intermetatarsal spaces, and exercised the usual abducting action upon the middle digit. Occasionally they are found greatly enlarged. Thus in a Horse, which was dissected last winter session (1880–81) in Dick's Royal Veterinary College, Edinburgh, Mr. M'Fadyean, the Professor of Anatomy, informs me that the fleshy bellies of these muscles were several inches long and proportionately thick; indeed, each exceeded in size a strongly-marked plantaris muscle in man.

[1] Comparative Anatomy, Fleming's Translation, p. 154.
[2] *Loc. cit.*, p. 413.
[3] *Vide* Gamgee and Law, *loc. cit.*, p. 413; Chauveau's Comparative Anatomie, p. 311.

Veterinary anatomists rightly term these muscles "interossei," but they are in error, in so far that they consider them to be the interossei of the lateral digits, *i.e.*, the first and fourth dorsal interossei. These muscles have undoubtedly disappeared along with the digits to which they belonged.[1]

Bovidæ (Oxen).

In the Ox the two digits which are present represent the medius and annularis. The metatarsals corresponding to these toes are fused so as to constitute a single bone, the double constitution of which is marked (1) by a deep longitudinal furrow on its anterior surface, (2) by a slightly marked groove on its posterior aspect, and (3) by a notch on its inferior extremity which separates the two articular surfaces.

The suspensory ligament of the Ox shows its muscular origin in a still more striking manner than that of the Horse. It is an exceedingly powerful structure which rests upon the posterior face of the metatarsus; expanding somewhat as it descends, it divides opposite the junction of the middle and lower thirds of the fused metatarsal bones into five distinct portions; of these (1) two go to the annularis; (2) two to the medius; and (3) one passes forwards in the notch which separates the two articular surfaces on the lower end of the metatarsus. The slips which go to the digits, have in each instance precisely the same insertion. They are inserted one into each of the sesamoid bones at the base of the first phalanx, whilst the marginal slip on each side sends forwards a strong flat band to be attached to the extensor tendon on the dorsum of the first phalanx of the corresponding toe. The remaining slip which passes forwards is central in position, and it reaches the dorsum of the foot in the interval between the two first phalanges of the digits. Here it splits into two diverging portions which join the extensor tendons on the dorsal aspect of the toes.

The suspensory ligament has thus two distinct insertions on each side of each digit, viz., into the sesamoid and into the extensor tendon, and in this manner an extremely powerful brace is formed, which very efficiently prevents over-extension at the metatarso-phalangeal joints.

But this ligament has also two additional attachments of an altogether different nature. From the middle of its superficial or posterior surface, two thick rounded tendinous looking slips arise. These pass downwards and, joining the tendons of the perforatus, take part in the formation of the double ring through which the two tendons of the perforans pass.

[1] We may at this stage refer to the foot of the Tapir. In Dr. Murie's admirable paper upon the Malayan Species (Jour. Anat. and Phys., vol. p. 166) the intrinsic pedal muscles are described and figured so clearly that although he speaks of them simply as single and double interossei, there is no difficulty in recognising their homologies. In this foot the hallux and minimus are absent. The plantar layer is composed of two muscles, viz., (1) the adductor indicis, and (2) adductor annularis. The intermediate layer consists of a strongly marked two-headed flexor brevis appropriated to each digit. No members of the dorsal layer are present, but it is very probable that they have fused with the strongly marked short flexors.

In the suspensory ligament of the Ox there is a large amount of muscular tissue, not only on its surface but also embedded in its interior. On the lower half of its superficial surface we find a thick layer of fleshy fibres. This is even continued down for some distance upon the slips into which the ligament divides. But it is upon the deep surface of the suspensory ligament that we observe the greatest quantity of muscular tissue. Here it extends from the origin of the structure down to the point where it subdivides, and it is disposed in three parallel and longitudinal strands; of these (1) one passes down to the angle of divergence of the two slips for the sesamoids of the medius, (2) another to the angle of divergence of the slips for the sesamoids of the annularis, whilst (3) the third is carried downwards between the two preceding to the central slip, and this is much the most strongly marked; indeed, at the lower part of the ligament, it extends right through the structure to its posterior or superficial surface. Each strand consists of short fibres arranged in an irregularly bipenniform manner.

When thin transverse microscopic sections of this ligament are made, the muscular tissue is seen to penetrate deeply into its substance. It is arranged in the form of four small circles or rings, with thick outlines placed side by side, nearer the anterior than the posterior surface of the structure (Pl. XI. figs. 8 and 8*a*.) It is present in much larger quantity than in the case of the Horse. When examined under the microscope these transverse sections show a considerable number of fat cells associated with the muscular fibres, and amidst these transversely cut nerves and blood-vessels.

But we must endeavour to determine the intrinsic muscle or muscles from which the suspensory ligament of the Ox is derived. In this we are aided by the definite arrangement of the muscular fibres. In the Horse only one muscle, viz., the flexor brevis medii, enters into its formation; in the Ox we have clear proof of at least two muscles. Each muscular ring seen in the substance of the transversely divided ligament represents the head of a flexor brevis. The ligament is thus formed by the union and fibrous degeneration of both heads of the flexor brevis medii, and of the flexor brevis annularis. The central slip of attachment which passes forwards between the digits, simply represents a portion of the outer head of the flexor brevis medii, and of the inner head of the flexor brevis annularis, proceeding to obtain an insertion into the extensor tendons.

No evidence exists to show that any of the other intrinsic muscles which usually belong to the medius and annularis are contained in this ligament.

But it may be asked, what do those tendinous cords which join the tendons of the perforatus homologate? Are they adductors, or indeed have they any muscular origin at all? I feel confident that they have not. Even before they separate from the ligament they have an appearance as if they hardly belonged to it, but constitute a thick layer on its superficial surface distinct from, although united to the body of the structure. I believe that they are derivations from the dense fascia, which invariably covers the

intrinsic muscles of the foot. This view is very strongly supported, as we shall see, by an examination of the foot of the Sheep.

Ovis aries (Sheep).

The bony framework of the foot of the Sheep is the same as that of the Ox. A study of this pes places the fascial derivation of the strong tendinous slips, which are given by the suspensory ligament of the Ox to the perforatus tendons, beyond a doubt. The suspensory ligament of the Sheep is covered by a dense aponeurotic membrane which is attached on each side to the margin of the metatarsus. This aponeurosis has no anatomical union with the ligament; indeed the ligament glides freely under it. It therefore represents the deep layer of fascia which is spread over the intrinsic muscles in other animals, and which is so strongly marked in the Baboon, and many other Apes (*vide* Bischoff[1]). Inferiorly it joins the tendons of the perforatus, not in cord-like processes, but by a flat ribbon-like band. This is unquestionably the homologue of the slips which spring from the superficial aspect of the suspensory ligament of the Ox, and by its union with the perforatus the rings, through which the tendons of the perforans pass, are formed.

The suspensory ligament of the Sheep has the same connections as that of the Ox. Its division into slips, however, takes place somewhat nearer the metatarso-phalangeal joints. Not a trace of muscular tissue is to be seen upon its superficial surface. A narrow inspection of its deep surface shows three delicate and parallel white streaks running in the long axis of the ligament, and occupying the same position as the strands of muscular fibres in the ligament of the Ox. On making thin microscopic sections of the structure we observe, with the naked eye, four rings, each with a delicate white outline, lying side by side in the substance of the ligament, and situated nearer the deep than the superficial surface (Pl. XI. figs. 9 and 9*a*). Under the microscope these outlines are seen to consist simply of fat cells, with here and there minute blood-vessels and nerves in their midst. Not a vestige of muscular tissue can be detected. In the Sheep, therefore, the fibrous metamorphosis of the intrinsic muscles has reached a more complete stage than in either the Horse or the Ox. Further, the microscopic examination of all these ligaments, but more especially that of the Sheep, appears to indicate that the process is effected by the fatty degeneration of the muscle fibres, with a concurrent increase of the connective tissue elements of the muscle. In all cases the change is more complete upon the superficial surface, and the blood-vessels and nerves of the muscles concerned are retained. On the deep surface of the ligament we always find a quantity of soft fat which, in the case of the Horse and the Ox, is so completely incorporated with the muscular fibres that it is impossible to remove it unless we take away at the same time the fleshy tissue.

With regard to the muscles which enter into the formation of the suspensory ligament

[1] Beiträge zür Anatomie des *Hylobates leuciscus*, München, p. 24, 1870.

of the Sheep, we conclude from the four fatty rings which are seen in its substance on transverse section that they are the same as in the Ox, viz., (1) the two heads of the flexor brevis medii, and (2) the two heads of the flexor brevis annularis.

Camelus bactrianus (Camel).

The foot I examined was that of a very young specimen. The suspensory ligament presents the same attachments as in the case of the Sheep. It gives off no slips to the perforatus tendon as in the Ox, and inferiorly it is very much flattened from before backwards. Unfortunately the pes had been injected with gelatine and carmine before it came into my possession, so that all the minute blood-vessels of the sheath of the ligament were full. It was therefore impossible to make out with certainty whether any muscular fibres were present on the surface. From the appearance presented, however, by transverse sections when examined by means of the microscope I am inclined to think that the conversion of the two flexores breves into ligamentous tissue is in this case complete. The Ox, the Sheep, and the Camel, therefore, illustrate very well three distinct stages in the metamorphosis.

The suspensory ligament of the Elk also appears to contain a considerable quantity of muscular tissue in its constitution.

Professor Morrison Watson, and Dr. A. H. Young in their paper upon this animal (On the Anatomy of the Elk, *Alces malchis*, Linnean Society's Journal, Zoology, vol. xiv.) give the following account of the ligaments:—The interossei "are represented almost entirely by a ligament corresponding to the suspensory ligament of the fetlock in the Horse. It consists of a stout musculo-tendinous band, which extends along the whole length of the metatarsus. The muscular portion does not appear to be arranged in any definite manner. Above the metatarso-phalangeal articulation the band divides into three portions, a central and two lateral; the central portion, after being connected to the sesamoid bones in this region, is inserted into the bases of the first phalanges of the two anterior toes; the lateral portions pass one along the outer, and the other along the inner, side of the metatarso-phalangeal joints to terminate on the dorsal aspect of the second phalanges of the anterior toes, by uniting with the extensor tendons."

Sus scrofa (Pig).

In the Pig the medius and annularis are largely and equally developed. The minimus and the index (*i.e.*, the marginal toes), whilst they are complete as regards the number of their segments, are short in comparison with the two central digits. The hallux is represented merely by an exceedingly minute rudimentary metatarsal bone.

The medius and annularis are enveloped in a common sheath of integument, and the weight of the body rests solely upon them. They are quite incapable of any movement of abduction and adduction.

In the Pig's foot a suspensory ligament is derived from members of the intrinsic group of muscles; but in this case certain of the dorsal interossei are called into requisition.

Adducting or plantar layer.—This layer is represented by two well-marked muscles, viz.:—

(1) The adductor indicis. (2) The adductor minimi digiti.

These muscles arise by a common origin from the central part of the base of the metatarsus, and then diverge from each other to reach their insertions. The adductor indicis is inserted into the outer sesamoid at the base of the first phalanx of the index, and also into the extensor tendon; the adductor minimi digiti is inserted in the same manner upon the inner aspect of the base of the first phalanx of the little toe.

The deep division of the external plantar nerve disappears under cover of the adductor minimi digiti, and can be traced inwards under the two plantar muscles, as far as the flexor brevis indicis in which it ends. It supplies all the intrinsic muscles.

Intermediate layer.—Each digit has a flexor brevis, although in no case does this muscle consist of two fleshy heads.

The flexor brevis indicis is represented by a well-marked fusiform tibial head which springs from the plantar and inner aspect of the base of the second metatarsal bone, and is inserted by a long tendon into the inner margin of the extensor tendon on the dorsum of the first phalanx of the index. In veterinary books (Chauveax, and Gamgee and Law) this muscle is termed a lumbrical and erroneously described as springing from the perforans. The outer fibular head is present in the form of a slender fibrous cord which stretches from the fibrous textures on the base of the third metatarsal bone to the outer sesamoid of the index.

The flexor brevis medii is a thick fleshy muscle composed of coarse fasciculi, which represent the tibial head alone. It lies upon the plantar face of the third metatarsal, from the base of which it takes origin. Approaching the metatarso-phalangeal joint it ends in a round tendon which is inserted into the inner margin of the extensor tendon on the dorsum of the first phalanx of the medius. A strong fibrous cord extends from the base of the third metatarsal to the outer sesamoid at the base of the same digit. It is difficult to determine whether this represents the outer head of the flexor brevis medii or the third dorsal interosseus (which is also absent) or both.

In the case of the annularis it is the fibular or outer head of the flexor brevis, which is present, and it presents exactly the same appearance as the preceding muscle. It

arises from the base of the fourth metatarsal, and is inserted into the extensor tendon on the outer aspect of the base of the annular digit. The inner or tibial head is represented by a very delicate fibrous slip inserted into the inner sesamoid.

The flexor brevis medii and flexor brevis annularis, lie directly under cover of the two adductor muscles, and are separated from them by the deep divison of the external plantar nerve.

The fibular head of the flexor brevis minimi digiti is the sole representative of this muscle, and as it is traversed throughout its whole length by a tendinous intersection, it is in all probability in combination with the abductor minimi digiti, which is absent as an independent muscle. It arises from the ligamentous textures at the base of the metatarsus, and is inserted upon the outer side of the base of the first phalanx of the minimus partly into the sesamoid, and partly into the extensor tendon.

Dorsal layer—In the Pig's foot we find no muscle belonging to this layer. The second and fourth dorsal interossei are converted into powerful ligamentous flattened bands which lie concealed in the second and fourth inter-metatarsal spaces. The former is inserted upon the inner face of the base of the medius partly into the sesamoid, and partly into the extensor tendon, and the latter is inserted similarly upon the outer aspect of the base of the first phalanx of the annularis. It is possible that the fibrous cord inserted into the outer sesamoid of the medius may represent the third dorsal interosseous muscle, but of this there is no decided proof.

But to what does this disposition, and, in some cases transformation, of the intrinsic muscles point? The short marginal digits are alone capable of lateral movement. They alone, therefore, retain their adductors, whilst their flexores breves are placed in such a position that when acting alone they exercise an abducting influence, and when acting in unison with the adductors they produce flexion.

With regard to the largely-developed annularis and medius in which lateral movement is prohibited, the function of the muscles usually set aside for this purpose is changed. Functionally we may look at these two digits as in reality one, and the muscles are arranged in accordance with this. The dorsal interosseus on each side of this double digit is converted into a strong ligamentous band. These two bands together act in a manner exactly similar to the suspensory ligament of the Horse, Ox, or Sheep; they prevent over-extension at the metatarso-phalangeal joints. The fibrous band inserted into the outer sesamoid of the medius also contributes feebly to produce this effect.

Of the four fleshy bellies which typically represent the flexores breves of the medius and annularis only two are retained, viz., the marginal bellies (*i.e.*, outer head of flexor brevis annularis and inner head of flexor brevis medii), and these together act as a short flexor for the double digit.

Hyracoidea.

Hyrax capensis.

The foot of the Hyrax is tridactylous—the hallux and minimus being absent. Of the three remaining digits the index alone possesses the three typical intrinsic muscles, whilst the medius and annularis each want an abductor. The myology of this interesting animal has been very fully worked out by Messrs. Murie and Mivart.[1] Even the minute intrinsic pedal muscles have not escaped their notice. They make no attempt, however, to classify these muscles, but merely describe them as single and double interossei. Their description is so accurate and exact that, in so far as the attachments of the muscles are concerned, I have little to add.

Plantar layer.—This layer is composed of two muscles, viz., (1) adductor indicis, and (2) adductor annularis. By Murie and Mivart they are named the second and fourth single interosseous muscles. In the figure which illustrates their description these muscles are represented as arising far apart from each other, and as being on the same plane as the other muscles. This is not the case, because proximally they are in contact and superficial, and they only diverge as they are traced towards their insertions. The adductor indicis arises from the fibrous structures on the plantar surface of the scaphoid bone, and is inserted into the fibular aspect of the base of the first phalanx of the index. The adductor annularis springs from the ligamentous tissue on the under surface of the cuboid, and is inserted into the tibial side of the base of the first phalanx of the annularis.

Intermediate layer.—Each digit is provided with a two-headed flexor brevis which lies upon the plantar aspect of the corresponding metatarsal bone, and has the usual connections; these muscles are termed by Murie and Mivart the double interossei.

Dorsal layer.—This group is only partially represented, the first and second dorsal interossei alone are present (first and third single interossei of Murie and Mivart).

The first dorsal interosseus or abductor indicis is a powerful muscle which arises from the inner and dorsal surface of the second metatarsal bone in its proximal half, and is inserted into the tibial side of the base of the first phalanx of the index.

The second dorsal interosseous muscle is not so strongly marked. It arises from the plantar aspect of the base of the middle metatarsal bone under cover of the adductor indicis, and is inserted into the inner aspect of the base of the first phalanx of the medius.

No trace of the two absent dorsal interosseous muscles is to be found. In all probability the third has coalesced with the outer head of the flexor brevis medii, and the fourth with the outer head of the flexor brevis annularis.

Messrs. Murie and Mivart noticed in their specimen muscular fibres arising from a ligamentous fascia upon the outer surface of the os calcis, and inserted into the head of the

[1] Proceedings of the Zoological Society of London, 1865, pp. 351, 352, 353.

fourth metatarsal, and they hint that this may possibly represent the abductor ossis metatarsi minimi digiti transferred in this instance to the annular digit. In the Hyrax which I examined I observed the thick ligamentous fascia upon the os calcis, but I could detect no muscular fibres in connection with it. I should imagine that this fascia, and the muscular fibres when they exist, undoubtedly represent that muscle undergoing retrograde changes.

Nervous arrangements.—The foot of the Hyrax presents one of the few instances in which we find a deviation from the usual and typical plan of nerve supply. The internal plantar nerve gives off a deep branch which sinks into the sole between those tendons of the flexor longus digitorum which go to the index and medius; after supplying twigs to all the intrinsic muscles of the index, this branch pierces the adductor indicis and ends in branches to the second dorsal interosseous muscle. The external plantar sends off a very minute deep division, which gives twigs to the flexor brevis annularis, and then dips under cover of the adductor annularis which it supplies.

Although I made a dissection of both feet of the specimen, I was unable to make out with precision the nerve-supply of the flexor brevis medii.

In dissecting the manus I was much interested to find that the same peculiarity in the nerve arrangements existed there. The median nerve supplies the muscles of the index, and ends in the outer head of the flexor brevis medii. The ulnar nerve supplies the muscles of the minimus and annularis.

The second dorsal interosseous muscle, which is supplied by the internal plantar in the foot, is absent in the hand. The fact of the outer head of the flexor brevis medii of the hand being supplied by the median may simply indicate that it contains in its midst the fibres of this lost interosseous muscle. In the manus, therefore, no less than in the foot, I am still doubtful as to the nerve supply of the short flexor of the middle digit.

Proboscidea.

Elephas indicus (Pl. XI. fig. 4).

Through the kindness of Professor Turner I have been able to examine the feet of a fœtal Indian Elephant, which has been preserved in spirit in the stores of the Anatomical Museum of the Edinburgh University for a great number of years.[1] The results I have obtained differ very slightly from those described by Messrs. Miall and Greenwood in their exhaustive paper upon the Anatomy of the Indian Elephant.[2]

In the disposition of its intrinsic muscles the foot of the Elephant is peculiar on account of the absence of the greater number of the plantar adducting and the dorsal abducting muscles. Encased as the digits are in the tough integument and the thick

[1] This specimen was described and figured by Professor Turner in the Jour. Anat. and Phys., July 1881.

[2] Journal of Anatomy and Physiology, vol. xii. pp. 286 and 287.

plantar cushion, they have little or no space wherein they can be separated and approximated, and consequently such muscles, had they been present, would have been almost functionless. Another remarkable feature in the foot of this animal is its resemblance to that of the Hyrax in the manner in which the intrinsic muscles derive their nerve supply. The intrinsic pedal muscles are entirely plantar in position.

The *plantar layer* consists of a single minute muscle—a transverse adductor of the index—which we may term the transversus indicis (p^2. *t*). This muscular slip arises from the head of the fourth metatarsal bone and the fascia covering the flexor brevis annularis, and passes transversely inwards upon the surface of the flexor brevis medii to be inserted into the fibular side of the sesamoid of the index.

Miall and Greenwood describe also an oblique adductor of the index which they term a "plantar interosseus." According to these authors this muscle "arises from the tarsus, opposite the bases of the third and fourth metatarsals, and is inserted into the fibular side of the base of the second digit." No such muscle existed in the fœtus dissected by me, but there was a strong fibrous band having precisely the same attachments, which I have no doubt is its representative (p^2).

Intermediate layer.—This is the only group of intrinsic muscles which is well developed. Each digit, with the exception of the hallux, is provided with a well-marked flexor brevis. These muscles are termed dorsal interossei by Miall and Greenwood.

The flexor brevis indicis (f^2) is the best marked muscle of the series. It consists of two heads, which arise from the fibrous textures in relation to the tendon of the peroneus longus, and are inserted one into each of the sesamoids on the plantar aspect of the base of the first phalanx of the index.

The flexor brevis medii (f^3) is also strongly marked, and composed of two heads which arise from the base of the middle metatarsal bone. The inner head also derives numerous fibres of origin from the fibular side of the fibrous cord which represents the oblique adductor indicis. The muscle is inserted in the usual manner into the sesamoids at the base of the medius.

The flexor brevis annularis (f^4) is more feebly developed. Its two heads are scarcely differentiated from each other, and its fibular slip passes for a short distance forwards into the fourth intermetatarsal space, which suggests the idea that combined with it is the absent fourth dorsal interosseous muscle. Like the preceding muscle it arises from the base of the fourth metatarsal, and is inserted into the sesamoids at the root of the annularis.

The flexor brevis minimi digiti consists of a single well-marked tibial head (f^5. *t*). From its taking a more proximal origin and from the stunted character of the metatarsal bone of the minimus this muscle does not lie in series with the other members of the group. Indeed, at first sight it is apt to be mistaken for an adductor, and Miall and Greenwood have described it as such. The fact, however, that all the deep branches of

the external plantar nerve run superficial to it points to its real nature. It arises from the under surface of the os calcis and from the calcaneo-cuboid ligament, and is inserted into the inner sesamoid bone of the minimus.

Dorsal layer.—This layer is composed of a strongly developed abductor minimi digiti, and the vestige of an abductor ossis metatarsi minimi digiti.

The abductor minimi digiti (d^6) is the largest of all the intrinsic muscles, and it has an unusual plantar position on account of the minimus being pushed inwards so as to lie in a plane posterior to the annularis. It arises from the under and anterior aspect of the tuber of the os calcis, and is inserted into the outer sesamoid of the minimus.

Abductor ossis metatarsi minimi digiti.—On the outer surface of the os calcis there is a dense fibrous band containing a number of muscular fibres; these do not extend so far forward as the fifth metatarsal bone. There can be little doubt but that they represent this muscle.

In the fœtus I examined the hallux was destitute of intrinsic muscles. In the specimen dissected by Miall and Greenwood there was a small flexor brevis hallucis.

Nerve-supply of the intrinsic muscles.—As in the case of the hyrax the internal plantar nerve (*i.p.n*) gives off a deep branch. This proceeds from the digital nerve, which divides to supply the contiguous sides of the medius and index. It is a twig of some size, and sinks into the sole to supply both heads of the flexor brevis indicis, and effect a junction with one of the deep branches of the external plantar nerve.

The external plantar nerve (*e.p.n*) sends off three deep branches which break up to supply the flexor brevis medii, the flexor brevis annularis, and the flexor brevis minimi digiti. The lowest of these twigs hooks round the transversus indicis, and supplying it with one or two small filaments communicates with the deep branch of the internal plantar. The abductor minimi digiti draws its nerve-supply direct from the trunk of the external plantar nerve.

Rodentia.

Lepus timidus (Hare), (Pl. XI. fig. 10).

The four outer toes of this foot are well developed, but the hallux is absent. The intrinsic muscles are so completely plantar in position that they are quite invisible from the dorsal aspect of the foot. The dorsal layer of muscles is not represented in this foot, and the plantar muscles are very feebly developed, and are evidently undergoing retrograde changes.

Plantar layer.—Two very minute muscular slips are the only representatives of this layer. They are (1) the adductor minimi digiti (p^5), and (2) the adductor indicis [1] (p^2).

[1] St. George Mivart and Murie, in speaking of the intrinsic muscles in the foot of the Hare, do not mention these adducting muscles. (Anatomy of the Crested Agonti, Proc. Zool. Soc., 1866, p. 415).

The adductor indicis (p^2) is the smaller of the two, and is very apt to be overlooked. They both arise by a common origin in the middle line of the foot from the ligamentous structures on the plantar aspect of the tarsus, and superficial to the other intrinsic muscles. Diverging from each other, they end in thread-like tendons which are inserted respectively upon the inner side of the base of the first phalanx of the minimus, and upon the outer aspect of the base of the same phalanx of the index. In both cases the insertion is into the extensor tendon and dorsal to that of the corresponding flexor brevis.

Intermediate layer (f^2 to f^5).—The members of this layer are strongly marked. On each metatarsal bone there is a powerful fleshy mass which, as it approaches the root of the corresponding toe, divides into two heads. These embrace the root of the digit, and are inserted partly into the sesamoids, and partly into the extensor tendon.

Dorsal layer.—Not a trace of abducting muscles is to be discovered. They are entirely lost. At the same time I am inclined to believe that they have coalesced with the flexores breves. It is true that there is very little outward evidence of this, only in fact, the presence of tendinous intersections traversing certain of the bellies of the flexores breves in lines along which such a fusion would take place.

Nerve arrangements.—The deep division of the external plantar nerve passes inwards under cover of the adductors, and supplies all the intrinsic muscles.

Bathyergus capensis (Pl. VIII. fig. 1) *and Mus capensis.* (Cape Mole and Cape Mouse).

The feet of these two animals are pentadactylous, and the intrinsic muscles are arranged upon identically the same plan in both. There is a total absence of the plantar adducting and the dorsal abducting muscles. The intermediate flexores breves, however are well developed, each consisting of two strong slips.

Whether the plantar and dorsal muscles are absent from suppression or fusion with the flexores breves it is impossible to make out. If it be due to the latter cause there are certainly no traces of the fusion to be discovered.

In both animals the same peculiarity in the arrangement of the intrinsic muscles of the hand is to be observed.

Castor fiber (Beaver).

The specimen of this species which I had an opportunity of examining was in a very putrid condition, but by a careful dissection of both feet I obtained a satisfactory view of the intrinsic muscles and their nerves of supply. There is a marked deficiency in the number of elements composing each of the three typical layers of pedal muscles, but those which are lost are for the most part represented in the foot by fibrous bands. The nerves have a very remarkable disposition.

Plantar layer.—The only muscular element of this layer is the adductor hallucis. It consists of a very minute short fleshy belly succeeded by a long slender fibrous band or

tendon. It springs from the fibrous structures on the deep surface of the middle cuneiform bone, and is inserted upon the outer aspect of the base of the first phalanx of the hallux. The adductor annularis is present in the form of a distinct fibrous band which rises from the tarsus beside the preceding, and is inserted upon the inner aspect of the base of the first phalanx of the annular digit. It contains no muscular fibres. Its position and connections alone tell its history.

Intermediate layer.—The three middle digits (*i.e.* index, medius, and annularis) are each provided with a well-marked and two-headed flexor brevis, which exhibits the usual connections. An aponeurotic band occupies the place of the inner head of the flexor brevis hallucis, whilst the outer head of the flexor brevis minimi digiti is represented by a slender fibrous cord. In the former a few fleshy fibres may be detected close to its origin.

Dorsal layer.—In this group we find—

1. An abductor hallucis. 2. Two dorsal interossei.
3. An abductor minimi digiti.

The abductor hallucis is a well-developed muscle which arises from the inner and under surface of the internal cuneiform bone, and is inserted into the inner sesamoid at the base of the hallux.

The first and second dorsal interossei are also well marked and present the usual insertions (viz., into the inner side of the base of the index and the outer side of the base of the medius respectively). They are single-headed muscles, and quite distinct from the flexores breves of these digits although closely applied to them.

A strong fibrous cord connects the shaft of the second metatarsal bone with the inner sesamoid of the medius. This may represent the second dorsal interosseus. Again, a strand of tough connective tissue which is attached by one extremity to the plantar aspect of the base of the fourth metatarsal bone and by the other to the outer sesamoid of the annularis may represent the fourth dorsal interosseus.

The abductor minimi digiti is a very feeble muscle.

Nervous arrangements.—In the foot of the Beaver there is very marked departure from the ordinary and typical distribution of nerves to the intrinsic muscles.

The internal plantar nerve divides into the usual four digital branches viz., (1), for the inner side of hallux, (2) for the adjacent sides of hallux and index, (3) for the adjoining sides of the index and medius, and (4) for the contiguous margins of the medius and annularis. From these, three muscular branches proceed for the supply of the intrinsic muscles. The first comes from the digital nerve to the inner side of the hallux and supplies the abductor hallucis. The second is the largest of the three, and takes origin from the third digital nerve. It sinks into the sole in the interval between the long flexor tendons which go to the index and medius, and breaks up into twigs which spread out to supply the adductor hallucis, the first dorsal interosseus, the flexor brevis indicis,

and the inner head of the flexor brevis medii. The third muscular branch springs from the fourth digital nerve and dips into the sole between those tendons of the flexor longus digitorum which go to the medius and annularis. It is destined for the supply of the flexor brevis medii—to both heads of which it gives filaments—and the third dorsal interosseus, but it likewise communicates on the one hand with the second muscular branch of the internal plantar and on the other with the terminal filament of the deep division of the external plantar nerve.

The deep division of the external plantar nerve is a very small twig, and ends in the flexor brevis annularis. The abductor minimi digiti is supplied by the superficial division of this nerve.

Cœlogenys paca (the Paca).

The foot of this rodent is pentadactylous. The hallux, however, is very rudimentary and the minimus is much smaller than the three central toes, which are nearly of an equal length. The plantar and intermediate layers of intrinsic pedal muscles in this animal are well represented. The dorsal layer is very deficient.

Plantar layer.—In this group there are three muscles, viz.:—

1. Adductor hallucis. 2. Adductor indicis. 3. Adductor minimi digiti.

They all arise by a common origin from the middle of the plantar surface of the tarsus, and, separating, they radiate from each other to reach their insertions. The adductor hallucis is inserted into the extensor tendon upon the outer side of the base of the hallux; the adductor indicis into the extensor tendon upon the same aspect of the base of the index; and the adductor minimi digiti into the extensor tendon upon the inner aspect of the base of the first phalanx of the minimus.

Intermediate layer.—As in the Beaver, the index, medius, and annularis have each a two-headed flexor brevis. This muscle springs from the base of the corresponding metatarsal, and its two heads, embracing the root of the toe with which it is connected, are inserted partly into the sesamoid and partly into the extensor tendon.

The flexor brevis minimi digiti has only a fibular head. This is a stout, fleshy belly which springs from the under surface of the external cuneiform bone, and is inserted into the outer sesamoid of the minimus.

The flexor brevis hallucis is represented by a tibial head which is much smaller than the preceding muscle. It arises from the under surface of the scaphoid, and is inserted upon the inner side of the first phalanx of the hallux.

Dorsal layer.—This layer is poorly developed. It has the following components:—

1. The abductor hallucis.
2. The second and fourth dorsal interossei.
3. The abductor ossis metatarsi minimi digiti.

The abductor hallucis is exceedingly small and closely applied to the tibial head of the flexor brevis hallucis. In great part fibrous, it arises from the scaphoid, and is inserted upon the inner side of the nodular first phalanx of the hallux.

The second and fourth dorsal interossei are strong, single-headed muscles which act as abductors of the index and annularis from the middle toe. There is no trace to be found of the other two interosseous muscles.

The abductor ossis metatarsi minimi digiti hardly deserves the name of a muscle. It is merely a stout fibrous band with an admixture of fleshy fibres which presents the attachments of this muscle.

Nervous arrangements.—The intrinsic muscles are supplied in the usual manner—the abductor and flexor brevis hallucis by the internal plantar nerve; the others by the external plantar. It is to be noted that the deep division of the latter nerve crosses the foot subjacent to the plantar muscles, and that it gives off the digital branch for the adjacent sides of the annularis and minimus. This branch reaches its destination by emerging from under cover of the adductor minimi digiti.

A comparison of the feet of the foregoing members of the Rodent order shows what seems to be a tendency to the disappearance of the plantar and dorsal muscles, but a retention of the intermediate muscles. The following table renders this evident:—

Plantar layer.

Paca	Three strongly developed adductors.
Hare,	Two feeble adductors.
Beaver,	One very weak adductor (with traces of a second).
Bathyergus, Cape Mouse,	None.

Dorsal layer.

Paca,	Four members of this group (two very weak).
Beaver,	Four members of this group (one very weak).
Hare, *Bathyergus*, Cape Mouse,	None.

Intermediate layer.

Cape Mouse, *Bathyergus*, Paca,	Five members of this group.
Hare,	Four members of this group.
Beaver,	Three members of this group (with traces of two others).

Further, according to St. George Mivart and Murie,[1] we may class with the *Bathy-*

[1] On the Anatomy of the Crested Agonti (Proc. Zool. Soc. Lond., 1866, p. 415).

ergus and Cape Mouse the Crested Agonti and the Guinea Pig, in both of which flexores breves are alone developed.

Cheiroptera.

Pteropus (Fox-bat), (Pl. XI. figs. 1 and 2).

The foot of the Fox-bat is pentadactylous—the four outer toes being of nearly equal length, and the hallux slightly smaller. All the digits are armed with sharp curved claws. The intrinsic muscles are well marked, but the dorsal or abducting members of the group, with one exception, are absent. They are all placed upon the plantar aspect of the metatarsus, and are all but invisible from the dorsal aspect of the foot.

Plantar layer.—Only two muscles of this layer are represented, viz.:—

1. Adductor hallucis (p^1).
2. Adductor minimi digiti (p^5).

These muscles together form a thin triangular sheet of muscular fibres spread out upon the flexores breves, but separated from them by the deep division of the external plantar nerve (*d.d*). This muscular sheet arises by its apex from the plantar surface of the tarsus somewhat nearer the inner than the outer margin of the foot, and it is mapped out into the two adducting muscles by a distinct fibrous raphe which extends from the apex to the base. The distal end of the raphe is not attached, and ends close to the inner side of the root of the medius. The adductor minimi digiti is much the larger of the two muscles, and is inserted into the inner sesamoid at the base of the first phalanx of the minimus. The adductor hallucis, small in proportion to the preceding, is inserted into the outer sesamoid at the base of the first phalanx of the hallux.

Intermediate layer.—This layer is typically complete (f^1 to f^5). A flexor brevis is provided for each digit; each muscle consists of two heads, and these are separate throughout their entire length. This group therefore is composed of eight distinct muscular slips, all of which lie upon the same plane. They arise from the fibrous textures at the base of the metatarsus and are inserted into the sesamoid bones alone.

The outer head of the flexor brevis minimi digiti, and the inner head of the flexor brevis hallucis, are considerably larger than the others. This increase in bulk may be due to their having coalesced with the absent abductor minimi digiti, and abductor hallucis.

Dorsal layer.—The only member of this layer which is present is the abductor ossis metatarsi minimi digiti (d^6). It is well developed, and has the usual connections. Not a trace of the dorsal interossei is to be found.

Nervous arrangements.—The posterior tibial nerve divides into its two terminal branches in the hollow of the os calcis.

The internal plantar nerve (*i.p.n*) on entering the sole at once breaks up into four digital branches :—These are distributed as follows :—(1) the innermost goes to the inner side of the hallux and gives three minute twigs to the large inner head of the flexor brevis hallucis ; (2) the next divides to supply the adjoining margins of the hallux and index, and gives a muscular twig to the first lumbrical ; (3) the third bifurcates and supplies the adjacent borders of the index and medius, and furnishes a filament to the second lumbrical ; (4) the fourth in like manner supplies the contiguous sides of the medius and annularis, and gives a twig to the third lumbrical. From the trunk of the internal plantar, before it breaks up into its digital branches, a few filaments are furnished to the flexor brevis digitorum.

The external plantar nerve (*e.p.n*) turns outwards under cover of the flexor brevis digitorum, and after supplying the abductor ossis metatarsi minimi digiti with one or two twigs divides into its superficial and deep divisions. The superficial part ends in two digital branches, of which one goes to the outer side of the minimus, whilst the other bifurcates to supply the adjacent borders of the minimus and annularis. The latter gives a twig to the fourth lumbrical which enters its plantar surface, and it is to be noted that in passing to its distribution it lies superficial to the flexor tendons and lumbricals. The deep part of the nerve turns inwards upon the flexores breves and under cover of the adductors, and reaching the inner margin of the sole it ends in the substance of the outer head of the flexor brevis hallucis. In addition to this, it supplies twigs to the adductors and to both heads of each of the four outer flexores breves.

There are two points in which this arrangement of the nerves is peculiar, viz. : (1) in the two outer lumbricals receiving their nerve supply upon their superficial aspect, and in the nerve to the third coming from the internal plantar ; (2) in the outer head of the flexor brevis hallucis receiving its nerve supply from the deep part of the external plantar.

I am quite aware that it may be objected that this muscle is not the outer head of the flexor brevis hallucis, but the oblique adductor hallucis. In answer to this I can only state that the muscular slip in question lies in series with the other flexores breves ; that in fact it is a flexor brevis in every respect except its peculiar nerve supply. It is further to be remembered that a large fan-shaped adductor hallucis is present, superficial to the short flexores (p^1).

Quadrumana.

Of this order of Mammalia I have only examined the feet of a Lemur, of a New Guinea Baboon (*Cynecophalus sphinx*), and of a large Monkey of which I merely possessed the partially skinned foot, and therefore could not determine with certainty the species. I believe, however, that it had been taken from a specimen of *Ateles*. The

vast amount of information which has already been furnished upon the anatomy of this order rendered further investigations on my part unnecessary. Professor Bischoff[1] of Munich, who is perhaps the greatest living authority upon the structure of the Ape, and its relation to that of Man, has added greatly to our knowledge in this respect, and so also have Huxley,[2] Duvernoy,[3] Vrolik,[4] Halford,[5] Macalister,[6] Champenys,[7] Ruge,[8] Murie and Mivart,[9] and many others. Except in the case of the three specimens, above quoted, the following facts are borrowed from the writings of these distinguished authors.

I have found the memoirs mentioned below especially useful in the present research. I regret, however, that I have not had an opportunity of studying Professor Halford's papers, and have thus been obliged to trust for my information regarding them to other memoirs in which they are noticed.

Plantar layer.—In the Quadrumana the adducting apparatus of the digits is usually very powerful, and further, it is plantar in position. Owing to the wide range of movement which is possessed by the opposable hallux, the adductor hallucis is developed to an extent far beyond the adductors of the other toes. It is in this group of animals that we observe for the first time a decided tendency in this muscle to split up into two parts, viz., an adductor obliquus hallucis, and an adductor transversus hallucis (*i.e.*, the transversalis pedis). Throughout Mammalia we occasionally see traces of a transverse adductor in connection with one or other of the muscles belonging to the plantar layer, but these are few in number, and the instances in which they occur have little direct bearing upon each other. In the Tamandua, Sloth, Elephant, and apparently also in the Armadillo, a transverse adductor of the index has been observed; again, in the Walrus a transverse adductor hallucis is present, and as we have noted, both Meckel and Ruge also consider the adductor hallucis in the Virginian Opossum to be double.

Bischoff in his memoir upon the *Hylobates leuciscus* gives an admirable account of the adductor hallucis in a great number of Apes. He shows that in the Gorilla, *Hylobates leuciscus*,[10] *Cynocephalus maimon*, *Cercopithecus sabäus*, and *Macacus cynomolgus* the two heads of this muscle are present as separate and distinct elements, whilst in the Orang,[11]

[1] Beiträge zur Anatomie des *Hylobates leuciscus*, München, 1870; Beiträge zur Anatomie des Gorilla, München, 1879.

[2] Structure and Classification of Mammalia (Lectures delivered before the Royal College of Surgeons), Medical Times and Gazette, 1864.

[3] Des caractères anatomiques des grands singes pseudo-anthropomorphes, Archives du Museum, tom. viii.

[4] Recherches d'Anatomie sur le Chimpansé, 1841.

[5] Not like Man, Bimanous, and Biped, nor yet Quadrumanous, but Cheiropodous, Melbourne, 1863; Lines of Demarcation between Man, Gorilla, and Macaque. Melbourne, 1864.

[6] Article on the Gorilla, Proc. Roy. Irish Academy, vol. i., ser. ii. pp. 501 and 504.

[7] On the Muscles and Nerves of a Chimpanzee and a *Cynocephalus anubis*, Journal of Anatomy and Physiology, vol. vi. pp. 187 and 203.

[8] Zur vergleichenden Anatomie der tiefen Muskeln in der Fussohle, Morph. Jahr., 1880.

[9] Anatomy of the Lemuroidea, Transactions of the Zoological Society, vol. xii.

[10] In the text (p. 39) the author states that in *Hylobates* the two muscles are coalesced, whilst in the table at the end of the work he says that they are "beide getrennt und stark."

[11] Bischoff asserts that the two heads are separate. Ruge, however, figures the muscle as a single fleshy mass (fig. 54).

Chimpanzee, *Pithecia hirsuta*, and the *Hapale pencillata* both are present, but they are coalesced so as to form a single muscular mass. In the Lemur the two muscles are largely developed, and although they lie side by side are yet easily separated from each other.

The foregoing facts have an important bearing upon the development of these muscles in the human foot. Dr. Ruge[1] has conclusively proved that the transversalis pedis or adductor transversus at an early stage in the development of the human embryo lies in apposition to the adductor obliquus, and that its transverse position in the foot of the adult is due to its travelling forwards towards the heads of the metatarsal bones. The occasional absence of the adductor transversus in Man, together with the fact that, in the young subject, it is always better marked than in the adult (Ruge) would seem to indicate that this muscle is undergoing regressive changes (probably from the confinement of the foot in a boot, and the consequent limitation of the range of movement of the hallux) and that in the course of time it will disappear altogether, or only appear occasionally as an interesting abnormality.

A study of the other members of the plantar layer in the Quadrumana yields results of an equally interesting nature. As a general rule all three (viz., the adductor indicis, adductor annularis, and adductor minimi digiti) are present, so that the plantar group of muscles is represented by its typical number of elements. These are inserted so as to draw the digits towards a line drawn through the medius. The following abstract from Bischoff's memoir upon the *Hylobates leuciscus* will show the arrangement of the adductors :—

Cynocephalus maimon.
Macacus cynomolgus.
Cercopithecus sabaeus.
Pithecia hirsuta.
Ateles.

Plantar layer consists of

1. Adductor hallucis (the two heads of which may be separated or united).
2. Adductor indicis.
3. Adductor annularis.
4. Adductor minimi digiti.

To this list we may add the *Cebus apella* (Ruge) and the Lemur,[2] in both of which the same factors of this group of muscles are found.

Hapale penicillata. Plantar layer consists of

1. Adductor hallucis (the two heads united).
2. Adductor indicis.
3. Adductor minimi digiti.

[1] Processes in the Development of the Muscles of the Human Foot, Morphologisches Jahrbuch, 1878, p. 132.

[2] Murie and Mivart in their memoir upon the Lemuroidea figure and describe only two adductors (in addition to the adductor hallucis), one "going to the peroneal side of the flexor of the index" and the other "going to the tibial side of the fifth digit." In the specimen I dissected there was also an adductor annularis, but it was feebly developed and partially fused with the subjacent muscles. The deep division of the external plantar nerve passed under it, and on detaching the other two adductors from their origin and throwing them forward it also was raised. Its feeble development may be due to abduction taking place, with reference to the annularis. Ruge, on the other hand, in his article upon the deep muscles of the sole of the foot (p. 649), says :—"In the Lemurs, in Loris gracilis, I could find contrahentes for all and even the third toe. The first contrahens (abductor hallucis) consists of two quite distinct heads."

Chimpanzee.[1] *Hylobates leuciscus.*	Plantar layer consists of	1. Adductor hallucis (two heads united in first, but separate in the second). 2. Adductor minimi digiti.
Orang. Gorilla.	Plantar layer consists of	1. Adductor hallucis (two heads united in first, but separated in second).

From this table it will be observed that, whilst in the majority of the animals quoted, the plantar layer is complete, a diminution in the number of its elements can be traced through the *Hapale* and the Chimpanzee and *Hylobates* until we come to the Orang and Gorilla in which there is merely the adductor hallucis. But the Orang seems to stand intermediate between the Gorilla, in which not a vestige of the absent muscles is to be found, and the other apes in which they are present. Ruge has shown in his important article upon the "deep muscles of the foot,"[2] that in this animal the place of the lost adductors of the second, fourth, and fifth toes is taken by tough strands of connective tissue, and that the nature of these is borne out not only by the deep division of the external plantar nerve lying subjacent to them, but also by the presence in connection with them of weakly developed muscular fibres. The regressive changes, therefore, by which these muscles have disappeared are very clearly indicated in the foot of the Orang.

Intermediate layer.—In the Quadrumana we never find a complete layer of flexores breves, *i.e.*, a two-headed muscle provided for each toe. The flexor brevis hallucis and the flexor brevis minimi digiti generally retain their two slips, but the flexor brevis annularis and the flexor brevis indicis are often represented by a single head, whilst the flexor brevis medii seems in the great majority of cases to be absent.

According to Bischoff the Gorilla,[3] the Chimpanzee, the *Hylobates*, the *Cynocephalus*,

[1] Since writing the above I have had the opportunity of examining the foot of a young Chimpanzee. The adductors were three in number, viz.: (1) adductor hallucis, (2) adductor minimi digiti, and (3) adductor annularis. The adductor hallucis was represented by an oblique and a transverse part, both of which were very strongly marked, and in close apposition to each other, but yet quite separable. A very interesting point in connection with the adductor obliquus hallucis was that it was supplied by twigs from both plantar nerves; the internal plantar nerve sent a branch into its superficial surface, whilst the terminal filaments of the deep division of the external plantar nerve sank into its deep surface. Nor could it be said that this double nerve supply was due to its having amalgamated with the outer head of the flexor brevis hallucis, because this muscle was present, although greatly reduced in size from being pressed deeply into the sole by the largely developed adductor. The adductor minimi digiti was well marked, and arose from a central raphe common to it and the transverse adductor of the hallux. The adductor annularis was exceedingly feeble, and took origin from the deep surface of the raphe which separated the adductors of the great and little toes; further, it was partially coalesced with the subjacent interossei, and could not be raised without lacerating muscular fibres.

[2] *Loc. cit.*, p. 650.

[3] Duvernoy and Macalister both describe the flexor brevis hallucis in the Gorilla as consisting of an inner head alone. Bischoff, however, points out that the former has regarded the true outer head as corresponding to the interosseus primus volaris in the hand, whilst the latter has, in all probability, looked upon it as an opponens, a muscle of which Bischoff could find no trace.

the *Cercopithecus*, the *Macacus*, the *Pithecia*, and the *Hapale*, all possess a two-headed flexor brevis hallucis. In many cases, as for example in the Gorilla and *Hylobates*, the outer head is very weakly developed, and as this author expressively terms it "pressed into the deep" by the adductor obliquus. In the Orang it is fused with the oblique adductor, and the double constitution of the muscle thus formed is manifested by its receiving its nerve-supply partly from the internal plantar nerve, and partly from the deep division of the external plantar nerve (Ruge [1]).

But Ruge is of opinion that the outer head of the flexor brevis hallucis must be regarded as a derivative of the inner head of the same muscle. He says: [2]—"In *Ateles* the flexor brevis is a single muscle which is sharply separated from the adductor obliquus by the tendon of the long flexor. It is inserted into the inner sesamoid bone. In *Cercopithecus* the outer flexor is only represented by distal muscular fibres that run from the inner sesamoid bone, under the tendon of the long flexor to the outer sesamoid bone. In *Cebus* these muscular bundles under the long flexor tendon are separate, and now indeed represent a perfectly distinct muscle. It lies between the inner flexor and the oblique head (of the adductor), covered by the tendon of the long flexor."

From these facts, however, we might argue in the opposite direction, and suppose a process by which the outer head, already developed, is gradually reduced in size, and finally absorbed by the inner head. We consider this the more likely interpretation, seeing that a two-headed flexor brevis hallucis is by no means an uncommon occurrence in the lower Mammals.

In the *Cynocephalus sphinx* a very beautiful example is afforded of the manner in which the outer head of the flexor brevis hallucis is reduced in size, and pressed deeply into the interval between the adductor obliquus and inner head of the flexor brevis so as to assume, in fact, a position corresponding to that of a plantar interosseous muscle. In the Lemur there is no trace of the outer head. The oblique adductor [3] is largely developed, but as it draws its nerve supply from the deep division of the external plantar alone, it is not likely that it contains in its midst the lost head of the flexor brevis hallucis.

Flexor brevis minimi digiti.—It is commonly asserted that this muscle in the Ape consists of a single external head. I believe, on the other hand, that it is almost invariably two-headed.[4] The inner head, however, (as is so frequently the case with the outer head of the flexor brevis hallucis) is very often pressed deeply into the sole so that its identity becomes obscured. It is then described under the cognomen of the "third plantar interosseous," muscle.

[1] *Loc. cit.*, p. 651. [2] *Loc. cit.*, p. 654.

[3] Murie and Mivart describe and figure this muscle under the name of flexor brevis hallucis (*loc. cit.*, p. 86, fig. 30, pl. vi., *f.b.h*).

[4] In the Chimpanzee which I dissected, the inner head of the flexor brevis minimi digiti (third plantar interosseus) was alone present. The outer head was absent, or rather completely converted into an opponens. In the Chimpanzee which Rolleston examined, this also was the case, but Champneys found an outer head in his specimen.

This inner head is very graphically represented in the drawings of the foot of the *Cynocephalus maimon* which accompany Bischoff's memoir upon the *Hylobates leuciscus* (Pl. IV. fig. 1, *h*, and fig. 2. III.). It can also be seen, although less distinctly, in Ruge's figures of the feet of the *Cebus apella* and Orang (pl. xxxv. figs. 52, 53 and 54). In the *Cynocephalus sphinx* it is very evident, and its association with the outer head of the flexor brevis minimi digiti is marked not only by its lying upon the same plane, but also by both having a common origin from the base of the fifth metatarsal. In the foot of the *Ateles* (?) it has a corresponding origin, but as we trace it towards the metatarso-phalangeal joint it sinks gradually into the fourth inter-metatarsal space, and is inserted into the extensor tendon on the dorsum of the first phalanx of the minimus. In the Lemur it presents precisely the same disposition as in the preceding animal.[1]

With regard to the other members of the intermediate group, a considerable reduction takes place in the number of their elements. In *Cynocephalus sphinx* the flexor brevis indicis is represented by the outer head alone, and the flexor brevis annularis by the inner head alone. These muscles are distinguished from the dorsal interossei not only by their insertions but also by being altogether invisible from the dorsal aspect of the foot. The flexor brevis medii is represented by a single small fleshy slip, which arises from the base of the fourth metatarsal bone and, crossing the third metatarsal obliquely, joins the second dorsal interosseous muscle near its insertion. In Bischoff's drawings of the foot of the *Cynocephalus maimon* (before referred to) the inner head of the flexor brevis annularis, and the outer head of the flexor brevis indicis are figured, but they are named the second and first plantar interossei. The flexor brevis medii is evidently completely gone. In the *Ateles* (?) a similar arrangement is observed, but here indications are to be found which would seem to point to the fact that the lost elements of the intermediate layer have coalesced with certain of the dorsal interossei. On removing the plantar adducting muscles, and also the two heads of the flexor brevis minimi digiti, we are confronted with what appear to be three bicipital muscles lying upon the second, third, and fourth metatarsal bones. These strongly resemble the amalgamated flexores breves and dorsal interossei of the tetradactylous carnivora. A closer examination, however, and an inspection of the dorsal aspect of the foot, will show that the muscles under consideration consist of four bipenniform dorsal interossei, the outer head of the flexor brevis indicis and the inner head of the flexor brevis annularis. The short flexors of the index and annularis are placed not only upon the side, but also upon the plantar aspect of the corresponding metatarsal, and they are united by their margins with the first and fourth dorsal interossei respectively. Further, it is very evident that fibres which appear to rise with those of the short flexors are prolonged upon the thick rounded tendons of the first and

[1] The two heads of the flexor brevis minimi digiti are well seen in fig. 30, pl. vi., illustrating Murie and Mivart's Memoir upon the Lemuroidea.

fourth dorsal interossei to be inserted into the outer sesamoid bone of the annularis in the one case and the inner sesamoid bone of the index in the other case. I believe that these fibres, thus incorporated with those dorsal interosseous muscles, represent the lost outer head of the flexor brevis indicis, and the lost inner head of the flexor brevis annularis. Then, with regard to the medius, we notice a thin stratum of muscular fibres, covering the plantar aspect of the middle metatarsal bone, and uniting the plantar margins of the second and third dorsal interossei. This bifurcates lower down, and the two fleshy slips thus formed run along the tendons of these dorsal interossei to be inserted into the sesamoids of the medius. I am inclined to believe that these slips, although incorporated with the dorsal interossei, represent the flexor brevis medii.

In the Lemur the flexor brevis annularis is apparently absent; the flexor brevis medii has two heads; but its inner head, almost immediately after its origin, joins the second dorsal interosseous muscle, and cannot be regarded as having an independent insertion; the outer head of the flexor brevis indicis is alone present. Murie and Mivart, in their memoir upon the Anatomy of the Lemuroidea, include these muscles under the heading of interossei. They say :—"In *Lemur catta* there are two to each digit, except the hallux, and counting the flexor brevis minimi digiti as one." They are, however, easily distinguished from the dorsal interossei from the latter being feebly bipenniform and also from the fact that the flexores breves can only be seen from the plantar aspect of the foot.

Dorsal layer.—This layer is generally represented by its complement of muscles. The abductor minimi digiti is usually more strongly developed than the corresponding muscle of the hallux, and as a rule it springs from the tuber of the os calcis. An abductor ossis metatarsi minimi digiti is also frequently present although not always separable from the preceding muscle. In the *Cynocephalus sphinx* it is very feebly represented; in the *Ateles* (?) it is absent, and in the Lemur it is strongly marked. In the Chimpanzee the abductor ossis metatarsi is absent.

The abductor hallucis, whilst it takes origin, in many cases, from the os calcis, is often very poorly developed. In *Cynocephalus sphinx* it is a very small slip which springs from the internal cuneiform bone; in *Ateles* (?) it arises from the scaphoid, and in the Lemur from the plantar fascia.

The dorsal interossei may be one-headed muscles, as in *Cynocephalus sphinx*, and arise from the bases of the metatarsal bones, or they may be bipenniform, as in the Chimpanzee, *Ateles* (?), Lemur, &c., and spring from the shafts of the metatarsals between which they lie. The first member of the series, owing to the first and second metatarsals being so far apart, is usually two-headed.

In all the Quadrumana, with two exceptions, the dorsal interossei are inserted so as abduct the toes from a line drawn through the medius, as is the case in the human hand: thus the first is inserted upon the inner side of the base of the first phalanx of the index;

the second and third are inserted one upon either side of the base of the first phalanx of the medius; and the fourth is inserted upon the outer side of the base of the first phalanx of the annularis. The two exceptions to this rule are—(1) the Gorilla, and (2) the Lemur.

Bischoff[1] has recently shown that in the Gorilla the pedal dorsal interossei are arranged in the same manner as in the human foot, viz., with reference to a line drawn through the index or second toe. Duvernoy[2] and Macalister,[3] however, differ from Bischoff upon this point, and consider the foot of the Gorilla no exception to the general rule, and therefore it is possible that the disposition of these muscles in this animal may vary.

In the Lemur I find that the dorsal interossei are arranged with reference to a line drawn through the annularis. The first is inserted upon the inner side of the base of the index; the second upon the same side of the base of the medius; and the third and fourth upon either side of the base of the annularis. This is very evident when these muscles are dissected from the dorsal aspect of the foot.[4] In the manus the dorsal interossei are arranged upon the same plan. Duvernoy considers the peculiarity of arrangement in the human foot to be due to the fact that the index which constitutes the centre for the movements of abduction and adduction is the longest of the toes. It is interesting to note in connection with this that the annularis is the longest digit in the foot of the Lemur. In the Gorilla, on the other hand, the medius is the longest toe.

Bimana.

We must now endeavour to determine the relation which exists between the intrinsic muscles of the human foot, and those of the feet of the lower animals. There is no difficulty in recognising the members of the dorsal layer. They are—

1. The abductor hallucis.
2. The abductor minimi digiti.
3. The occasional abductor ossis metatarsi minimi digiti.
4. The four dorsal interossei.

The plantar layer is represented by (1) the adductor hallucis, and (2) the transver-

[1] Beiträge zur Anatomie des Gorilla—Aus den Abhandlungen der K. bayer Akademie der W. II., clxiii. Bd. iii. Abth.

[2] *Loc. cit.* [3] *Loc. cit.*

[4] This is very clearly and beautifully represented in plate lxxv. (figs. 1 and 2) of the Atlas (vol. ix.), which accompanies the text (vol. vi.) of the great work which has recently appeared entitled "Histoire Physique, Naturelle et Politique de Madagascar," by M.M. Alph. Milne-Edwards and Alfred Grandidier. In the text of vol. vi. which is devoted to the Lemurs, reference is made in page 191 to this disposition of the dorsal interossei, but the authors hardly seem to have realised its full importance. They say:—"Dans l'intervalle qui sépare le troisième métatarsien du quatrième, et celui-ci du cinquième orteil existent deux interosseux dorsaux qui se fixent de chaque côté de la premiere phalange du quatrieme orteil." In the case of the manus it is neither figured nor described.

salis pedis, whilst the flexor brevis hallucis and the flexor brevis minimi digiti belong to the intermediate layer.

So far there can be no dubiety; but to which layer are we to relegate the three plantar interosseous muscles? In two short abstracts of portions of this Report which I published in the Journal of Anatomy and Physiology,[1] I placed these three muscles in the plantar layer, and therefore, classed them with the adductor obliquus and adductor transversus hallucis. In doing so I followed in a great measure the views of Meckel.[2] Such views, however, I now consider to be erroneous, and I believe that the plantar interrossei in reality belong to the intermediate or flexor group of muscles. This opinion is based upon the following facts:—

(1) In the quadrumana we have traced the gradual disappearance of all the adductor muscles except those belonging to the great toe.

(2) We find plantar interossei not only in those apes which have a complete adducting apparatus (*e.g.* *Cynocephalus*), but also in those in which it is only represented by the adductors of the hallux and fibrous bands (*e.g.* Orang), and in those in which it is reduced, to the adductors of the great toe alone (*e.g.* Gorilla).

(3) Ruge[3] has pointed out that the deep division of the external plantar nerve, as it runs inwards across the sole, is placed between the adducting muscles and the other

[1] Intrinsic Muscles of the Manus of *Thylacine*, *Cuscus*, and *Phascogale*, Jour. Anat. and Phys., vol. xiii. p. 443. Intrinsic Muscles of the Mammalian Foot, Jour. Anat. and Phys., vol. xiii. p. 12.

[2] The views held by J. F. Meckel regarding the homologies of the intrinsic muscles of the human hand and foot may be gathered from the following quotations from his work entitled "Descriptive and Pathological Anatomy," translated from the French by A. S. Doane, M.D., and published in 1839. In Vol. I. p. 283, he says:—"The proper muscles of the thumb and little finger are only the lumbricales or interossei muscles largely developed and divided into several fasciculi. We must consider the flexor pollicis brevis muscle as the first lumbricalis. The abductor pollicis brevis and the opponens pollicis correspond to an external (*i.e.* dorsal); the adductor represents an internal (*i.e.* palmar) interosseous muscle. The abductor and flexor brevis minimi digiti muscles form only one muscle, which represents the last external interosseous muscle. The adductor minimi digiti (opponens) muscle is only an enlarged internal interosseous muscle." Then in page 318 he advances the following opinions regarding the intrinsic muscles of the foot: "The muscles of the large and the small toes may be referred to the other muscles of the foot, as we have seen those of the thumb and little finger could be to the other muscles of the hand. The abductor pollicis pedis is the first external interosseous muscle, and the posterior belly of the abductor? (adductor obliquus) the first internal interosseous muscle. The anterior belly of the latter (adductor transversus) represents the first lumbricalis. . . . The abductor minimi digiti is the last external interosseous muscle. Finally, the flexor brevis minimi digiti may be considered as belonging to the flexor digitorum communis, because of the slight development of the fourth tendon of the latter in most subjects." The words in brackets have been introduced by myself.

The close association of the flexor brevis pollicis and the flexor brevis minimi digiti with the long flexor tendons has evidently suggested to this author the view that these muscles in the hand are simply exaggerated and highly developed lumbrical muscles. It is not borne out, however, by an examination of the same muscles in the hand and foot of lower animals; indeed a totally different view of the case is suggested. We have seen that the short flexors of the marginal digits in many animals lie in series with three other muscles, which have precisely the same relation to the index, medius and annularis as they have to the first and fifth digits. It is reasonable, therefore, to conclude that they all belong to one group. But an additional argument is afforded against Meckel's theory by Dr. Young of Manchester, in his paper upon the "Intrinsic Muscles of the Marsupial Hand" (*loc. cit.*). In his dissection of the hand of the yellow-footed Rock Kangaroo he noticed that the pollex was furnished with a lumbrical muscle in addition to its two-headed flexor brevis.

[3] "Upon the Comparative Anatomy of the Deep Muscles in the Sole of the Foot (*loc. cit.*, p. 645).

members of the intrinsic group. This is a most useful, and, as a general rule, a most reliable guide in determining the muscles which belong to the plantar layer. He says the deep division "sinks at the outer edge of the contrahentes (*i.e.*, adductors) between these and the interossei. This nerve courses inwards, constantly placed on the interossei and covered by the contrahentes and giving branches to both groups." Now in Man this nerve passes inwards superficial to the plantar interossei and under cover of the adductor obliquus hallucis, thus cutting them off from each other.

(4.) In a foot dissected in the Practical Anatomy Rooms of the University of Edinburgh this summer session (1881), I observed a distinct fleshy slip proceeding from the outer edge of the adductor obliquus hallucis to be inserted into the outer side of the base of the first phalanx of the index. This clearly represented the adductor indicis.

The flexor brevis minimi digiti is a single-headed muscle which is inserted into "the base and external border of the first phalanx of the little toe" (Quain). I believe that the third plantar interosseus is the inner head of this muscle.

FIG. 2. Schematic view of the intrinsic muscles of the left human foot—seen in transverse section through the metatarsus. The lost elements are sketched in dotted outline. Compare with figure 3.

(f^1) Flexor brevis hallucis. ($f^3\ t$) Tibial head of flexor brevis medii (1st plantar interosseus). ($f^4\ t$) Tibial head of flexor brevis annularis (2nd plantar interosseus). ($f^5\ t$) Tibial head of flexor brevis minimi digiti (3rd plantar interosseus). ($f^5 f$) Fibular head of flexor brevis minimi digiti. (p^1) Adductor obliquus hallucis. (d^1) Abductor hallucis. (d^6) Abductor minimi digiti. (d^2 to d^5) Dorsal interossei. (I. to V.) Metatarsal bones. (*e.p.n*) External plantar nerve giving off its superficial and deep division.

The remaining two plantar interossei (viz., the second and first) are the flexores breves of the annularis and medius, which have lost their outer heads, and have taken on an adducting action in consequence, antagonising in this respect the action of the fourth and third dorsal interossei.

Nor need we consider this change of function remarkable when we have already seen in the Horse a short flexor converted into a powerful ligament; in the Sloth

the flexores breves wandering to the dorsum of the foot and acting as extensors; and in some marsupial and monotrematous animals a new and opposite action added to the abductors, viz., that of approximation.

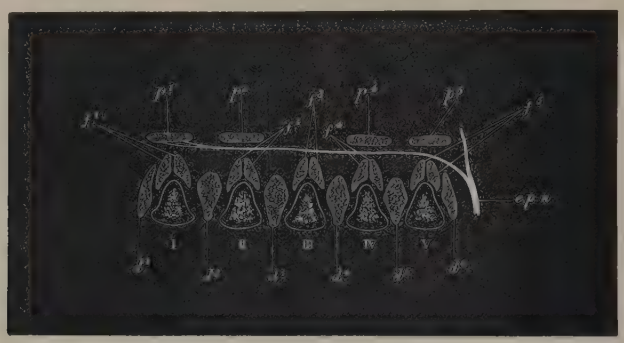


FIG. 3. Schematic view of a transverse section through the metatarsus of a typical foot.

(p^1 to p^5) Adductores. (f^1 to f^5) Flexores breves. (d^1 to d^6) Abductores. (*e.p.n.*) External plantar nerve.

The flexor brevis indicis is completely lost in the human foot—not a trace of it is to be found.

General Remarks.

Plantar layer.—To Bischoff and Halford is due the credit of being the first to describe an adducting muscular apparatus homologically distinct from the other intrinsic muscles of the hand and foot. Bischoff's observations were confined to the Apes, and he did not include as a part of this apparatus the adductor hallucis. It is true that many writers had previously noted the presence of adducting muscles, but all had failed to recognise their true import. Professor Halford not only gives an account of the muscles composing this layer in the foot of the Macacus, but he applies to them the distinctive name of "contrahentes digitorum"—a name which Bischoff adopts. In the abstract of this portion of my report which I published in the Journal of Anatomy and Physiology in 1878, I described these muscles in a large number of the lower mammals, and placed the adductor hallucis amongst them. To the group thus constituted I gave the name of "plantar layer of adductors." In this paper, however, I fell into the error of considering the plantar interossei of the human foot as members of the layer. A few months later, Ruge's article upon the Deep Muscles of the Sole of the Foot appeared, in which he also recognised the true position of the adductor hallucis by placing it amongst the contrahentes or adductors. Further, he pointed out, by means of the deep division of the external plantar nerve, that the adductores digitorum

were distinct from the plantar interossei. He offered no suggestions regarding the homologies of the latter beyond stating that they were "interossei." In his former paper upon the Development of the Muscles of the Human Foot, he includes the flexor brevis minimi digiti with the musculi interossei pedis.

Subjoined is a tabular view of the distribution of the adducting muscles in Mammals.

The asterisk (*) is placed at the point towards which the adducting muscles operate. Where the + is used, the muscle in the corresponding column is absent.

Plantar Layer—Adductores. (Table A.)

Pentadactylous Feet.

	Adductor hallucis.	Adductor indicis.	Adductor medii.	Adductor annularis.	Adductor minimi digiti.
Echidna setosa,	Present *	Present	Present	Present	Present
Phascolarctos cinereus,	,,	,,	,,	,, +	,,
Ornithorhynchus paradoxus,	,,	+	,,	,,	,,
Dasyurus viverrinus,	,,	Present	+	,,	,,
Phascogale calura,	,,	,,	+	,,	,,
Didelphys virginiana,	,,	,,	+	,,	,,
Dasypus sexcinctus,	,,	,,	+	,,	,,
Cynocephalus maimon (Bischoff),	,,	,,	+	,,	,,
Macacus cynomolgus (Bischoff),	,,	,,	+	,,	,,
Cercopithecus sabaeus (Bischoff),	,,	,,	+	,,	,,
Pithecia hirsuta (Bischoff),	,,	,,	+	,,	,,
Ateles,	,,	,,	+	,,	,,
Cebus apella (Ruge),	,,	,,	+	,,	,,
Lemur,	,,	,,	+	,,	,,
Cuscus maculata,	,,	+	...	,,	,,
Phalangista vulpina, Specimen A,	,,	+	...	,,	,,
Phalangista vulpina, Specimen B,	,,	Present	...	+	,,
Myrmecophaga tamandua,	,,	,,	...	+	,,
Meles taxus,	,,	,,	+	...	,,
Lutra vulgaris,	,,	,,	+	...	,,
Mustela putorius,	,,	,,	+	...	,,
Cœlogenys paca,	,,	,,	+	...	,,
Hapale penicillata (Bischoff),	,,	,,	+	...	,,
Pteropus,	,,	...	+	...	,,
Chimpanzee (Bischoff),	,,	...	+	...	,,
Hylobates leuciscus (Bischoff),	,,	...	+	...	,,
Trichechus rosmarus,	,,	...	...	...	...
Castor fiber,	,,	...	...	...	...
Orang (Bischoff),	,,	...	+	...	...
Gorilla (Bischoff),	,,	...	...	...	...
Homo,	,,	...	...	...	...
Elephas indicus,	...	Present	...	...	...
Bathyergus capensis,	...	...	...	...	...
Mus capensis,	...	...	...	...	...
34	31	21	3	16	26

Plantar Layer—Adductores. (Table A)—*continued.*

Tetradactylous Feet.

(*Hallux* absent, or very rudimentary.)

	Adductor indicis.	Adductor medii.	Adductor annularis.	Adductor minimi digiti.
Thylacinus harrisii,	Present	+	Present	Present
Canis familiaris,	,,	+	,, (?)	,,
Dingo (Australian Wild Dog),	,,	+	...	,,
Felis catus,	,,	+	...	,,
Felis concolor,	,,	+	...	,,
Felis leopardus,	,,	+	...	,,
Felis leo,	,,	+	...	,,
Sus scrofa,	,,	+	...	,,
Lepus timidus,	,,	+	...	,,
Macropus robustus,	...	...	...	,,
10	9	...	2	10

Tridactylous Feet.

	Adductor indicis.	Adductor medii.	Adductor annularis.
Hyrax capensis,	Present	+	Present
Bradypus tridactylus,	...	...	...

This table brings out that the plantar layer constitutes a very constant part of the intrinsic muscle apparatus of the mammalian foot. In the feet of forty-six different species possessed of three or more toes it is absent entirely in three cases only. In the monodactylous and didactylous feet of Solipeds and Ruminants not a trace of adducting muscles is to be found. But, further, the table shows the relative constancy of the different members of the group. The starting-point is the *Echidna*, in which there are five muscles, one for each toe. Ruge[1] considers the original number to be six, and he describes that number in the *Ornithorhynchus*, viz., two for the minimus, and one for each of the other digits. One of the two which he refers to the minimus we have already seen to be in reality the outermost belly of the flexor brevis digitorum, and not an intrinsic muscle at all. Although I was unable to find an adductor indicis in the four specimens of this animal I examined, I would consider that its occasional presence is a very likely occurrence seeing that it is constantly present in the Echidna. A glance at the table will show that

[1] Upon the Comparative Anatomy of the Deep Muscles of the Sole of the Foot.

whilst five is the original number, there is a distinct tendency exhibited for the adductors to disappear from the centre of the foot towards the margins, and this disappearance takes place in a more marked degree in an outward direction towards the minimus than in an inward direction towards the hallux. Thus the adductor hallucis and the adductor minimi digiti are the most constant—the former or more internal of the two much more so than the latter or more external. The adductor indicis and adductor annularis rank next in point of constancy, but the adductor indicis, which is the more internal of the two, is more frequently present than the adductor annularis. The central adductor, viz., the adductor medii, was only found in three specimens. The sudden disappearance of this adductor is probably due to the tendency which these muscles have to arrange themselves so as to act with reference to the middle toe. The exact ratio of constancy of the different members of this group of intrinsic muscles can be seen by a reference to the table.

Intermediate and dorsal layers.—At the end of Ruge's paper upon the Deep Muscles in the Sole of the Foot[1] there is the following statement:—"During the printing of this work I notice that D. J. Cunningham divides the deep muscles of the mammalian foot into three divisions—(*a*) plantar (adductores), (*b*) intermediate (flexores breves), (*c*) dorsal (abductores). I hold it incorrect to extend this subdivision to all mammals, especially since, even according to Cunningham, a fusion of layers *b* and *c* is very common."

I fail to perceive wherein Dr. Ruge should consider this classification of the intrinsic muscles "incorrect," seeing that throughout his two papers he indirectly admits it. Thus he makes the great primary division into (1) contrahentes, and (2) interossei, and then he divides the latter[1] into (*a*) a palmar, and (*b*) a dorsal series. Is this not a clear subdivision into three layers, or in other words, a trilaminar arrangement? The muscles of the minimus and the muscles of the hallux he describes as two separate groups. Why he should consider the muscles of the marginal digits distinct from those of the other toes I cannot understand. I have found no grounds upon which we can base a difference, beyond the fact that from the more commanding position of these toes it frequently happens (more especially in the case of the minimus) that their muscles have undergone greater development, and it may be segmentation.

Dr. Young of Manchester in answer to Ruge's criticism remarks:—"It is difficult to understand why the fusion of two previously existing layers, however common, should in any way militate against the view that the separate condition was more typical than the coalesced; conversely, indeed, if the fact of their fusion be in all cases established, it certainly seems to favour Dr. Cunningham's views of the type arrangement." I cannot take advantage of this argument, forcible though it be, because I do not consider that we

[1] *Loc. cit.*, p. 657.

[2] In his Memoir upon the development of the foot (*loc. cit.*) he says, "In the group of interossei pedis which at present with general acceptance is divided into the four outer or dorsal, and the three plantar or inner, I include the flexor brevis minimi digiti, &c. &c."

have in every case clear proof that muscles when absent are lost by fusion (as for example the Hare, the Fox-Bat, the *Bathyergus*, the Cape-Mouse, &c. &c.).

If we study the subjoined tabular views of the intrinsic pedal muscles in mammalia, a considerable amount of light is thrown upon the relations of the different layers to each other. We notice—(1) that the intermediate group is the most constant of the three layers; (2) that the dorsal layer is the least constant, and the most variable, in several cases being wholly unrepresented; (3) that there is a striking tendency to fusion between the members of the intermediate and dorsal groups of muscles; and (4) that the plantar muscles almost invariably remain distinct from the subjacent muscles.

Intermediate Layer—Flexores Breves. (Table B.)

Pentadactylous Feet.

	Flexor brevis hallucis.	Flexor brevis indicis.	Flexor brevis medii.	Flexor brevis annularis.	Flexor brevis minimi digiti.
Cuscus maculata,	Both heads	Both heads	Both heads	Both heads	Both heads
Didelphys virginiana,	,,	,,	,,	,,	,,
Bathyergus capensis,	,,	,,	,,	,,	,,
Mus capensis,	,,	,,	,,	,,	,,
Pteropus,	,,	,,	,,	,,	,,
Trechechus rosmarus,	Fibular head tibial head (?)	,,	,,	,,	,,
Phascogale calura,	Tibial head	,,	,,	,,	,,
Lutra vulgaris,	,,	,,	,,	,,	,,
Phalangista vulpina,	Both heads	,,	,,	,,	Fibular head
Phascolarctos cinereus,	,,	,,	,,	,,	Tibial head
Dasyurus viverrinus,	Tibial head (fused with abductor)	,,	,,	,,	Both heads
Ornithorhynchus paradoxus,	Tibial head	,,	,,	,,	...
Meles taxus,	Both heads	,,	Tibial head	Tibial head	Both heads
Elephas indicus,	...	,,	Both heads	Both heads	Tibial head
Cœlogenys paca,	Tibial head	,,	,,	,,	Fibular head
Castor fiber,	...	,,	,,	,,	...
Myrmecophaga tamandua,	Tibial head	Tibial head	Tibial head	Tibial head	Both heads
Ateles,	Both heads	Fibular head	...	,,	,,
Cynocephalus sphinx,	,,	,,	Tibial head	,,	,,
Lemur,	Tibial head	,,	Both heads	...	,,
Homo,	Both heads	...	Tibial head	Tibial head	,,
Echidna setosa,	,,	Tibial head	...	...	Fibular head
Armadillo,	,,	...	...	...	,,
	Both heads, 13 Tibial head, 7 Fibular head, 1	Both heads, 16 Tibial head, 2 Fibular head, 3	Both heads 16 Tibial head, 4 Fibular head, ...	Both heads, 15 Tibial head, 5 Fibular head, ...	Both heads, 15 Tibial head, 2 Fibular head, 4
Total, 23	Total, 21	Total, 21	Total, 20	Total, 20	Total, 21

Intermediate Layer—Flexores Breves. (Table B)—*continued.*

Tetradactylous Feet.

(*Hallux* suppressed, or very rudimentary.)

	Flexor brevis indicis.	Flexor brevis medii.	Flexor brevis annularis.	Flexor brevis minimi digiti.
Thylacinus harrisii,	Both heads	Both heads	Both heads	Both heads
Lepus timidus,	,,	,,	,,	,,
Canis familiaris,	Both heads (fused with dorsal interossei)	Both heads (fused with dorsal interossei)	Both heads (fused with dorsal interossei)	Both heads (fibular head fused with abductor minimi digiti)
Dingo (Australian Wild Dog),	,,	,,	,,	,,
Felis catus,	,,	,,	,,	,,
Felis concolor,	,,	,,	,,	,,
Felis leopardus,	,,	,,	,,	,,
Felis leo,	,,	,,	,,	,,
Sus scrofa,	Tibial head	Tibial head	Fibular head	Fibular head
Macropus robustus	,,	,,	Both heads	Both heads
	Both heads, . . 8 Tibial head, . . 2	Both heads, . . 8 Tibial head, . . 2	Both heads, . . 9 Fibular head, . 1	Both heads, . . 9 Fibular head, . 1
Total, 10	Total, 10	Total, 10	Total, 10	Total, 10

Tridactylous feet.

	Flexor brevis indicis.	Flexor brevis medii.	Flexor brevis annularis.
Hyrax capensis,	Both heads	Both heads	Both heads
Bradypus tridactylus,	...	...	...

Dorsal Layer—Abductores. (Table C.)

Pentadactylous Feet.

	Abductor hallucis	First dorsal interosseus.	Second dorsal interosseus.	Third dorsal interosseus.	Fourth dorsal interosseus.	Abductor minimi digiti.
Phascogale calura,	Present	Present	Present *	Present	Present	Present. 2 parts—for metatarsal and for phalanx.
Didelphys virginiana,	,,	,,	,, *	,,	,,	Present. 3 parts—for metatarsal, for sesamoid, and for extensor tendon.
Myrmecophaga tamandua,	,,	,, +	,,	,,	,,	Present. 2 parts—for metatarsal and for phalanx.
Lutra vulgaris,	,,	,,	,, *	,,	,,	Present. 1 part only, viz., abductor metatarsi.

Dorsal Layer—Abductores. (Table C)—*continued.*

Pentadactylous Feet—continued.

	Abductor hallucis.	First dorsal interosseus.	Second dorsal interosseus.	Third dorsal interosseus.	Fourth dorsal interosseus.	Abductor minimi digiti.
Dasyurus viverrinus,	...	Present	Present *	Present	Present	Present. 3 parts: (1) for metatarsal, (2) for sesamoid, (3) for extensor tendon.
Ornithorhynchus paradoxus,	..	,,	Present (approximator)	Present (approximator)	,,	Present. 1 part only, viz., abductor metatarsi.
Meles taxus,	...	,,	Present *	Present	,,	Present. 1 part only, viz., abductor metatarsi.
Castor fiber,	Present	,,	... *	,,	...	Present.
Cœlogenys paca,	,,	,,	... *	...	Present	Present. 1 part only, viz., abductor metatarsi.
Cuscus maculata,	,,	,,	...	Present (approximator)	,, (approximator)	Present. 3 parts: (1) for metatarsal, (2) for sesamoid, (3) for extensor tendon.
Phalangista vulpina,	,,	,,	...	Present (approximator)	Present (approximator)	Present. 2 parts: (1) for metatarsal. (2) for phalanx.
Homo,	,,	,, *	,,	Present	Present	Present.
Cynocephalus sphinx,	,,	,,	,, *	,,	,,	Present. 2 parts: (1) for metatarsal, (2) for phalanx.
Ateles,	,,	,,	,, *	,,	,,	Present.
Lemur,	,,	,,	,,	,, *	,,	Present. 2 parts: (1) for metatarsal. (2) for phalanx.
Phascolarctos cinereus,	,,	,,	...	...	...	Present. 2 parts: (1) for metatarsal, (2) for phalanx.
Echidna setosa,	,,	...	Present (approximator)	...	...	...
Dasypus sexcinctus,	,,	...	...	...	...	Present. 2 parts: (1) for metatarsal, (2) for phalanx.
Trechechus rosmarus,	,,	...	...	Present	...	Present. 3 parts: (1) for metatarsal, (2) for sesamoid (?) (3) for extensor tendon (?).
Elephas indicus,	...	...	...	...	...	Present.
Bathyergus capensis,	...	...	...	...	...	...
Mus capensis,	...	...	...	...	...	...
Pteropus,	...	...	...	..	...	...
23	16	16	12	15	14	(1) Total number of times present in one or other form. 19
			2 Approximators	3 Approximators	2 Approximators	(2) Abductor ossis metatarsi. 15
			10 Abductors	12 Abductors	12 Abductors	(3) Single abductor minimi digiti. 11
						(4) Double abductor minimi digiti. 4

Dorsal Layer—Abductores. (Table C.)—*continued.*

Tetradactylous Feet.

	First dorsal interosseus.	Second dorsal interosseus.	Third dorsal interosseus.	Fourth dorsal interosseus.	Adductor minimi digiti.
Thylacinus harrisii, . .	Present	Present *	Present	Present	Present. 3 parts: (1) for metatarsal, (2) for sesamoid, (3) for extensor tendon.
Canis familiaris, . . .	Present, but fused with the flexor brevis.	Present, but fused with the flexor brevis. *	Present, but fused with the flexor brevis.	Present, but fused with the flexor brevis.	
Dingo (Australian Wild Dog), . . .	,,	,, *	,,	,,	...
Felis concolor, . . .	,,	,, *	,,	,,	Present. 2 parts: (1) for metatarsal, (2) for extensor tendon.
Felis leopardus, . . .	,,	,, *	,,	,,	Present. 3 parts: one of which is the abductor metatarsi.
Felis leo, ...	,,	,, *	,,	,,	Present. 2 parts: (1) for metatarsal, (2) for extensor tendon.
Lepus timidus, . . .	...	...	...	...	...
Sus scrofa, . . .	...	...	...	...	...
Macropus robustus, . .	...	...	...	..	...
9	6	6	6	6	(1) Total number of times present in one form or other. 4 (2) Abductor ossis metatarsi. 4 (3) Single abductor minimi digiti. 2 (4) Double abductor minimi digiti. 2

Tridactylous Feet.

	First dorsal interosseus.	Second dorsal interosseus.	Third dorsal interosseus.	Fourth dorsal interosseus.
Hyrax capensis, ...	Present	Present	...	...
Bradypus tridactylus, ...	,,	,,	Present	Present
2	2	2	1	1

All this points to an exceedingly close association between the intermediate and dorsal layers, and possibly also to the fact that the latter (*i.e.*, the dorsal interossei, the abductor hallucis, and the abductor of the minimus) may have originally been derived from the former (*i.e.*, the flexores breves). Ruge's researches into the development of the muscles of the human foot decidedly favour this view. He has shown that at a very early stage the muscles are plantar, and that it is only as development advances that the dorsal interossei pass upwards between the metatarsal bones.

It is interesting to note that whereas the adductor of the hallux is the most constant and frequently the most highly developed muscle of the plantar layer, it is the abductor minimi digiti which is the most constant and most highly differentiated member of the dorsal layer.

It is convenient to notice at this stage the criticism which Dr. Young has made upon the abstract of this portion of my report, which I published in 1878. He examined the hands of five Marsupials, viz., the Opossum, Wallaby, yellow-footed Kangaroo, Wombat, and Koala. From these dissections he concludes that, "with respect to the disposition of the intrinsic muscles of the hand and foot, a considerable number of Marsupials agree closely with what has been laid down as the actual type, upon which these muscles are arranged in the whole of the mammalia. But it does not appear that this 'type' is so constantly adhered to in any other group of the Mammalia; on the contrary, the deviations from it are so numerous and of such a nature as to render the justifiability of its extension to all mammals questionable." It is true that it is in "the Marsupials as a class that we find the typical arrangement most closely adhered to," but we have simply to glance over the foregoing tables to see that the mammals are very few indeed in which we do not find indications of all the three layers. Putting aside the plantar muscles as a layer about which there can be no dispute, it will be observed, that in every animal, with one exception (viz., the *Bradypus*), there is a distinct flexing group, and that in almost every case one muscle from this layer is allotted to each toe. The dorsal layer, although it is the most fully represented of the three groups in Man, is the one which in the lower animals is least constant and most variable. In very few instances, however, do we find it wholly unrepresented. Surely Dr. Young is not prepared to abolish this layer. If any is to be abolished it must be the dorsal layer.

But another paragraph in Dr. Young's article leads me to believe that he applies a wider meaning to the word typical than I have any intention to convey. He says:—"The history of the developmental changes, indeed, will afford the only sure data for the determination of that fundamental arrangement which alone can be considered as constituting an actual and inclusive type in contradistinction to one purely ideal or hypothetical." I have no wish to claim that the trilaminar arrangement is the fundamental or original disposition of the intrinsic pedal muscles in Mammalia. On the contrary I am strongly of opinion that it is not so, and I have already hinted that they are strong arguments in

favour of looking upon the dorsal muscles, as derived secondarily from the flexors. Fixity of structure is an impossibility. There are few cases, indeed, in which, either by comparative or developmental research, anatomists are able to penetrate so far into the obscurity which surrounds the history of the changes which structure undergoes as to found an absolute fundamental type. It is very questionable whether such is possible in any case. The three chief movements of a digit are adduction, flexion and abduction. When each digit is supplied with an independent intrinsic muscle for the production of each of these movements the three sets of muscles assume the trilaminar arrangement. Such a hand or foot is typical in so far as it presents an arrangement to which all other hands or feet can be referred.

The centre for the movements of adduction and abduction.—A decided tendency is exhibited throughout Mammalia generally for the adductors and abductors of the toes to arrange themselves with reference to the medius or middle digit. It thus comes about that the adductor medii disappears and two dorsal interossei or abductors are allotted to the medius, one for each side. There are a great number of exceptions to this rule. In *Echidna* adduction takes place towards the interval between the hallux and index; in the *Ornithorhynchus, Cuscus,* and *Phalangista vulpina* (?) towards the index; in the Koala, *Phalangista vulpina* (?), and Tamandua towards the annular digit. In other cases, where only one or perhaps two adductors are present, it is impossible to make out the exact point, although it may be presumed to be the central line of the foot. Exceptions in the case of the abductors are of rarer occurence. We may quote, however, Man, the Gorilla, and the Tamandua as marked instances in which the centre of abduction is the index, and the Lemur, as an instance in which the annular digit constitutes the centre. It sometimes happens that the centre of adduction does not correspond with that of abduction. The Tamandua and the Lemur are examples of this. In the former there is no adductor of the medius; but the line of origin of the three remaining adductors is over the metatarsal of the annularis, and therefore we conclude that they operate towards this digit, and that the adductor indicis in acting upon the index has an indirect influence upon the medius as well. The abductors are, on the other hand, distinctly arranged with reference to the index—two being appropriated to this digit, and the others being inserted into the outer sides of the medius, annularis, and minimus, and into the inner side of the hallux respectively. In the Lemur, whilst abduction takes place with reference to the annularis, adduction is effected with reference to the medius. The adductor annularis, however, which is rendered useless by the fact that this digit is supplied by two dorsal interossei is evidently fast disappearing, indeed it is not described by Murie and Mivart.

In the foot of Man, the Gorilla, &c., certain of the flexores breves by the loss of one of their heads became adductors, and thus placed themselves in antagonism to the abductors. In tables A. and C. the centres of adduction and abduction are indicated as far as it is possible to do so by the introduction of an asterisk (*).

Adaptation of the intrinsic muscle-apparatus to the requirements of the pes.—It is a question about which there can be no dispute that the number and arrangement of the intrinsic pedal muscles are in a great measure dependent upon the special functions required of the foot. It is disappointing, however, to find so little clear proof of this in the mammalian pes.

Let us take three well-marked examples of burrowing animals from different orders, viz., the *Echidna*, the *Bathyergus*, and the Badger, and compare the disposition of the intrinsic muscles of their feet. The result is found to be highly unsatisfactory. In the *Echidna* the only layer well represented is the plantar layer. Each digit is supplied with an adductor. Flexores breves on the other hand are only found in connection with the small hallux, the index and the minimus and abductores in connection with the hallux and index. In the *Bathyergus* the flexores breves are alone developed—one being furnished to each toe. Not a trace of adductores or of abductores exists. In the Badger all three layers are well represented; thus there are three adductors, five flexores breves, and five abductors.

If we next contrast the feet of four aquatic animals, viz., the Otter, the Beaver, the *Ornithorhynchus*, and the Walrus we obtain equally unsatisfactory results. In the Otter the intrinsic pedal muscles meet almost all the requirements of the typical trilaminar arrangement. Each digit is supplied with three muscles, with the exception of the annularis which wants an adductor. In the *Ornithorhynchus* the digits are also well furnished with intrinsic muscles, but these are arranged upon a different plan, and there is great difficulty experienced in separating the flexores breves from the dorsal interossei. The abductor hallucis, and the flexor brevis minimi digiti are absent; and further, the second and fourth dorsal interossei are developed into approximators. In the Beaver and Walrus, on the other hand, the plantar layer is only represented by a feeble adductor hallucis. With regard to the intermediate layer, the Walrus possesses a distinct flexor brevis for each toe, whereas in the Beaver the flexores breves are restricted to the index, medius, and annularis. The disparity in the dorsal layer is even more marked. In the Walrus there is a powerful abducting apparatus connected with the minimus, a very rudimentary abductor hallucis, and one questionable dorsal interosseus present, viz., the third. In the Beaver, the abducting apparatus of the minimus is feeble in the extreme; the abductor hallucis is well developed, and there are two well-marked dorsal interossei, viz., the first and the second.

In the dissection of these aquatic feet I was struck with the uniform feeble development of the abducting apparatus of the marginal digits. I fully expected that these muscles would be largely developed for the purpose of expanding the web. In the Walrus alone is the abductor minimi digiti well marked. In the Beaver it is very feeble, and in the *Ornithorhynchus* and Otter it is only represented by the metatarsal portion, viz., the abductor ossis metatarsi minimi digiti. Then with regard to the abductor hallucis: in the *Ornithorhynchus* it is absent, in the Walrus and Otter it is very feeble, and in the

Beaver alone is it a tolerably well developed muscle. On reflection, the reason of this weakness of the marginal abductors in aquatic feet becomes apparent. In the backward stroke of the pes the water, the resisting medium against which it strikes, is sufficient to cause the full expansion of the web. The flexores breves guard against over extension of the digits, and thus the long flexor muscle is free to act upon the ankle joint. Dr. Murie describes in the foot of the Sea-lion [1] (*Otaria jubata*) two short muscles which lie obliquely upon the under surface of the tarsus. They both arise from the scaphoid, and they are respectively inserted into the internal cuneiform, and into the base of the first metatarsal bone. He considers that they represent the adductor and flexor brevis hallucis, but as he figures a very distinct adductor for this toe, and also the fibular head of a flexor brevis hallucis, I think (as already explained) that it is more probable that they are homologous with the absent abductor hallucis and tibial head of the flexor brevis hallucis. But what has caused those muscles to assume these highly anomalous attachments? Dr. Murie states that "both are flexors"; one of the internal cuneiform upon the scaphoid and the other of the first metatarsal bone. In this manner therefore they support the tarsus and enable it to bear the strain which must be communicated to it by the backward stroke of the expanded digits through the water. In the Walrus [2] Dr. Murie found corresponding muscles, and in this animal, as we have seen, a special part of the abducting apparatus of the minimus is set aside apparently for the same purpose. This muscle stretches between the under surface of the os calcis and the base of the fifth metatarsal bone.

Let us now choose two terrestrial animals of similar habits, and which employ their feet for similar purposes, viz., the Dog and the *Thylacine*. Both these animals use their feet for progression, and it may be also occasionally for burrowing. In the latter case they employ them to clear away the earth which has been detached by their fore-paws. In both animals the feet are very similar in outward appearance, with the exception that the Dog is digitigrade, whilst the *Thylacine* is semi-plantigrade. The intrinsic muscles are disposed differently in each case. In the *Thylacine* the arrangement is typical in every respect; in the Dog the flexores breves and abductors are coalesced, and this withstanding the slow, skulking character of the *Thylacine* as compared with the highly active habits of the Dog.

Arboreal Marsupials almost invariably exhibit the typical disposition of their intrinsic muscles, *e.g.* the *Phascogale*, the Virginian Opossum, the Australian Opossum, the *Cuscus*, &c. The Koala is an exception, inasmuch as the dorsal layer is poorly represented. The arboreal Rodent, the Squirrel (*Sciurus vulgaris*) has, however, quite a different arrangement. The adductors and flexores breves are well developed, but the abductors are reduced to a single muscle, viz., the abductor minimi digiti.

[1] On the Anatomy of the Sea Lion, Trans. Zool. Soc., vol. vii. p. 579.
[2] On the Anatomy of the Walrus, Trans. Zool. Soc., vol. vii. p. 456.

From the above examples it is seen that very much the same functions may be performed by different feet by a great diversity of arrangements of the intrinsic pedal muscles. In the animals that we have compared, however, we must remember that we have only looked at the feet from one point of view, viz., that which bears chiefly upon the special mode of life adopted by the animal. We must not lose sight of the fact that the difference in structure in feet, which we might expect to find similar, may be due to many circumstances that we have not taken into account. The offices and duties required of the foot are very numerous and very diverse, and we cannot therefore classify them arbitrarily into burrowing, aquatic, terrestrial, and arboreal.

Dr. Young is of opinion that "the differentiation and development of the flexores breves" is for the purpose of providing for the maintenance of a "continuous and powerful flexion of the digits, without at the same time interfering with the free movements at the wrist." I am rather inclined to believe that the part which all the intrinsic muscles have to play is the production of the more rapid and precise movements of the digits, movements which could not be produced by muscles which arise in the forearm or in the leg, and which are inserted into the digits by means of long tendons. In a general sense, Dr. Young is decidedly correct in the observation which he makes, that those digits "which are endowed with the most independent powers, have invariably the most distinctly differentiated muscular arrangements; hence, even when the whole of the digits are supplied with the "typical" complement of muscles, the first and fifth are very commonly more favoured than the rest."

One cannot examine a large number of different Mammalian feet without being struck by the decided ordinal distinctions which the intrinsic muscles exhibit in their disposition. In Marsupialia, we have the tendency to the trilaminar disposition. In Monotremata there is the marked development of the adductors and the primitive condition of these as regards their insertion with reference to the middle line of the foot. In Carnivora the prominent feature is the coalescence (or shall we say the non-separation ?) of the flexores breves and dorsal interossei with the frequent development of an opponens minimi digiti from the plantar layer. In the Solidungula and Ruminantia, the flexores breves are converted into the suspensory ligament. In Rodentia there is the pre-eminence of the intermediate layer of the flexores breves. In the Quadrumana the muscles of the hallux are inordinately developed, and the adductor hallucis becomes split up into an oblique and transverse portion. In Homo and his more immediate allies of the Quadrumanous order, viz. the Gorilla and Orang, there is the loss of the plantar muscles, with the exception of the adductor hallucis and the loss also of certain of the heads of the flexores breves so that the remainder take on the function of the absent adductors. In the Edentata, which is composed of so many diverse forms, there is apparently no feature peculiar to all.

Nerve arrangements.—At the outset of this chapter upon the intrinsic pedal muscles we referred to the view which is held by certain anatomists, that the relationship between

"nerve-supply" and "muscle-homology" is invariable and immutable. It is well at this stage to inquire how far the nerve arrangements in the Mammalian foot bear out this doctrine.

In the great majority of cases the pedal nerves have precisely the same course and distribution. The two plantar nerves enter the sole by the hollow in the os calcis. The internal plantar nerve supplies the abductor hallucis and flexor brevis hallucis (when such muscles are present). The external plantar nerve turns outwards to reach the fibular margin of the foot, where it breaks up into a superficial and deep part. The former supplies the flexor brevis and abductors of the little toe, whilst the deep part turns inwards across the sole under cover of the plantar adducting muscles, and is distributed to all the adductors and to the other intrinsic muscles of the index, medius, and annularis. The rule therefore is, that with the exception of the flexor brevis and the abductor of the hallux, the external plantar nerve supplies all the intrinsic muscles of the foot. But this is not the invariable rule. Certain well-marked exceptions are met with.

In the Elephant the internal plantar nerve supplies the flexor brevis indicis; in the Hyrax the internal plantar nerve supplies the flexor brevis indicis, the adductor indicis, and the second dorsal interosseous muscle; in the Beaver, a still more remarkable deviation is found. From the internal plantar nerve proceed the twigs of supply for the abductor hallucis, flexor brevis indicis, flexor brevis medii, and the first and third dorsal interossei. Lastly, in the Fox-bat there is an example of the external plantar nerve encroaching upon the domain of the internal plantar by supplying a twig to the outer head of the flexor brevis hallucis.

The arrangement of the digital nerves is also not without interest. It follows a more constant plan than that of the muscular twigs. In a pentadactylous foot the internal plantar nerve gives off four digital branches, which are distributed to the hallux, the index, the medius, and the tibial side of the annularis. The external plantar nerve on the other hand provides two digital branches—one for the fibular side of the minimus, and the second for the adjacent sides of the minimus and annularis. In only one instance have I observed a marked deviation from this arrangement, viz., in the *Echidna*, in which the digital nerve for the contiguous margins of the annularis and medius comes from the deep division of the external plantar, and the twig, for the outer side of the minimus proceeds from the internal plantar.

The digital nerve for the adjacent margins of the minimus and annularis is somewhat variable in its origin. In the lower members of the Mammalian class (*Ornithorhynchus*, *Echidna*, *Cuscus*, *Vulpine phalanger*, *Paca*, &c.) this branch arises from the deep division of the external plantar, and reaches its distination by coming out from under cover of the adductor minimi digiti. In the Fox-bat, Quadrumana, and Man it springs from the superficial division of the external plantar nerve, and in its course downwards it is not covered by any muscular structure. In *Thylacine* an intermediate condition is

exhibited. The branch in question comes from the superficial division of the external plantar, but it is joined at its point of bifurcation by a large twig from the deep division.

Very few cases occur in which the plantar nerves deviate from the ordinary course. In the *Ornithorhynchus* we find the external plantar entering the foot upon the outer side of the os calcis, apart from the internal plantar. Again, in the *Echidna* the internal plantar gives off a branch which enters the foot by a similar route and replaces the superficial part of the external plantar nerve.

So constant, indeed, are these nerves in their relations that Ruge has been induced to make the generalisation that all those muscles which lie superficial to the deep division of the external plantar nerve are contrahentes. So far as I am aware this rule fails to apply to the foot in only two cases, viz., the *Dasyurus viverrinus* and *Dasyurus hallucatus*, in both of which the nerve passes under cover of one of the abductors of the minimus. The great objection to this method of classifying the adductors, however, is that it is incapable of being extended to the hand. In the Manus the deep division of the ulnar nerve passes inwards under cover of the flexor brevis minimi digiti, and also under (or through) the opponens minimi digiti, both of which, therefore, according to this generalisation would be looked upon as contrahentes or adductores.

Intrinsic muscles of the human hand.—The fact that abduction and adduction takes place in the human hand with reference to the middle digit constitutes the chief difference between the disposition of the intrinsic muscles of the Manus and pes in Man. The descriptions given of the short muscles of the thumb in works upon human anatomy are very misleading and at variance with the homologies of these muscles. The nerve supply is of itself sufficent to lead us to suspect this. In these text-books a single adductor pollicis and a flexor brevis pollicis, consisting of a superficial, and deep head, are described. The adductor and the deep head of the flexor draw their nerve filaments from the deep division of the ulnar, whereas the superficial head of the flexor is supplied by the median nerve. Bischoff many years ago pointed out the fallacy of this description, and insisted that the so-called adductor pollicis is in reality the adductor transversus (the homologue of the transversalis pedis), and that the so-called deep head of the flexor brevis is the adductor obliquus. These two muscles, which form a continuous muscular stratum, are separated from each by the entrance into the palm of the radial artery. But an inner or deep head of the flexor brevis is also present. This muscular slip, however, is not always described, and when it is noticed it has a different name applied to it, viz., the "interosseus volaris primus" of Henle. I entirely agree with Bischoff in his views upon the short muscles of the thumb; indeed, I had arrived at similar conclusions before I read his paper upon this subject. From a number of dissections made by Mr. Sheridan Delepine in the Practical Anatomy Rooms of the Edinburgh University, I am led to believe that the minute inner head of the flexor brevis pollicis is a constant muscular slip. It is quite invisible from the palmar aspect of the hand, and is best exposed from the dorsal aspect

by removing the first dorsal interosseus, or indeed by merely dividing the head of this muscle which springs from the first metacarpal bone. It is a very small muscular slip which, as Bischoff expresses it, has been "thrust into the deep," by the largely developed adductor obliquus. It lies in series with the palmar interossei.

In the tabular view, which is given in the eighth edition of Quain's Anatomy, of Muscular Homologies in the Upper and Lower Limbs, the relations between the muscles of the thumb and great toe are stated with tolerable accuracy with the exception that the position of the two heads of the flexor brevis pollicis is reversed. The following is an extract from that table :—

Flexor brevis pollicis, inner head, . .	Flexor brevis hallucis.
Flexor brevis pollicis, outer head, . .	Adductor hallucis obliquus.
Adductor pollicis, ...	Transversalis pedis.

In place of this the table should be constructed thus :—

Flexor brevis pollicis, ...	Flexor brevis hallucis.
(*a*) Radial head, ...	(*a*) Tibial head.
(*b*) Interosseus primus volaris, . .	(*b*) Fibular head.
Deep or ulnar head of flexor brevis pollicis, . . . } . .	Adductor obliquus hallucis.
Adductor pollicis, ... {	Adductor transversus hallucis (*i.e.* transversalis pedis).

II. The question now arises: If the intrinsic muscles of the foot are laid down in three layers, to which of these does the opponens muscle belong ?

It is necessary, however, before we inquire into this point that we should have a clear understanding what the muscles are to which the term "opponens" should be applied. We need not look to function for a true definition, for many of the opponens muscles have little or no opposing action. It is clearly the insertion which must be taken as the distinguishing feature, and we may define the term as being one which may be properly applied to any intrinsic muscle, which is inserted into the shaft of a metatarsal bone.

An opponens hallucis is a very rare occurrence. In his memoir upon the *Hylobates leuciscus* Bischoff remarks that among the Apes he has "only found it as a peculiar speciality in the Orang and Macacus." In the report of Lecture xvii. upon the Structure and Classification of Mammalia, delivered by Professor Huxley before the Royal College of Surgeons in 1864, and published in the Medical Times and Gazette, we find the following passage (vol. i. p. 596):—"There was present in the specimen (Orang), dissected by Professor Huxley, an opponens hallucis, inserted into the middle third of the meta-

tarsal of the hallux ; this has not been described by other authors, nor indeed is there any trustworthy evidence of the existence of such a muscle in any of the Mammalia."

Macalister (Proceedings of the Royal Irish Academy, vol. i., 2nd series, page 506) describes an opponens hallucis in the Gorilla. Bischoff, however, was unable to find such a muscle in the specimen which he dissected (Beiträge zur Anatomie des Gorilla, p. 31, *loc. cit.*).

An opponens minimi digiti is very common, and often very strongly marked. It may be regarded as belonging in some instances to the adducting or plantar layer, and in others to the intermediate or flexor layer. Thus Ruge has conclusively shown that in the human foot (when present) it is a special development of the flexor brevis minimi digiti. He says :[1] "in the earliest periods in the development of the human foot every trace of an opponens of the little toe is awanting. First by the aberration of fibres of insertion of the flexor brevis on to the head, and outer surface of the fifth metatarsal the beginning of an opponens becomes gradually noticeable ; in older subjects this becomes further developed, and more turned in direction until, finally, the whole outer surface of the fifth metatarsal serves for the insertion of the muscle. In preparations from later embryonic periods, the flexor and opponens fibres appear separate in their distal portions, so that the opponens reaches a greater and greater degree of independence the further the process of separation goes on. At the same time the opponens, now distinct, comes to lie under cover of the flexor. This condition remains throughout life, but still the muscle in the adult shows a decrease in its circumference, and may even have disappeared altogether. These conditions occur so very frequently that I may say they are the rule."

In the Lemur and in the phalanging marsupials the opponens minimi digiti has apparently the same origin as in man.

On the other hand many of the digitigrade Carnivora afford a beautiful example of its association with the plantar layer. We have already seen it in the Dog, Cat, Puma, Leopard, Lion, Otter, and Pole-Cat, arising in common with the adductor minimi digiti.

III. The last point that we have to consider is one of great interest, viz., that the relation of the intrinsic muscles of the foot to the metatarsus in many animals corresponds to transitory conditions in the foot of the human embryo.

Ruge in his memoir upon the Development of the Muscles of the Human Foot shows that the interossei muscles in the foot of the early embryo are plantar in position, and that the upward growth of the dorsal interossei and the formation of the interosseous spaces take place as a subsequent and gradual step. In three of the diagrams which illustrate the text he gives representations of sections through the metatarsus at three

[1] The Development of the Muscles of the Human Foot (*loc. cit.*), p. 131.

different periods of development. In the first the metatarsal bones, with the exception of the first two, are in close apposition, and in consequence all the interosseous muscles, excepting the first dorsal, are plantar in position. The second diagram is from a foot somewhat more advanced. It shows that as development progresses the metatarsal bones separate from each other, and that simultaneously with this the dorsal interossei begin to shoot up between them like wedges. The third illustration gives a view of the relative position of the muscles and metatarsal bones as they are to be seen in the adult. The bones are widely apart from each other, and the muscles have reached the dorsum of the foot.

Among the lower mammals there are many animals which in their adult condition correspond exactly with the first stage of the human embryo in the relation of their intrinsic pedal muscles to the metatarsus. Perhaps the Dog and the Dasyure are the best examples that I could quote. In these the metatarsals are closely compressed together, and the muscles are entirely plantar in position (Pl. VIII. fig. 4).

The majority of animals never reach beyond the second stage of the human embryo in this respect. Let us take the foot of the Leopard as an example. In this animal, the metatarsal bones, whilst they are closely applied to each other towards the tarsus, open out slightly from each other towards their phalangeal extremities; and in the intervals between them the thin sharp edges of the dorsal interossei may be seen reaching half-way up the interosseous spaces (Pl. VIII. fig. 7).

Comparatively few animals correspond with the third or adult condition of the human foot; still certain of the Apes approach very closely to Man in this respect.[1]

It is curious to find in an animal so low as the Duck-bill *Platypus* a closer approach to Man than in the vast majority of mammals. The dorsal interossei reach the dorsum of the foot, and, moreover, the second and third are two-headed.

But there is also a relation between the human embryo and many of the adult animals in the mode of origin of the dorsal interossei. Ruge points out that in the early embryo these muscles are one-headed, and that it is only in a later stage that they acquire their bipenniform character and their origin from the metatarsal shafts. How similar is this to what we have seen to be the permanent condition in the great majority of mammals.

[1] Mr. Champneys, when he wrote his well known paper upon the Chimpanzee and Anubis (Jour. Anat. and Phys., vol. vi. p. 207), had a very clear conception of the different conditions which the intrinsic pedal muscles presented to the metatarsus. The following is a footnote appended to his paper:—"Duvernoy remarks that in the Gorilla, as I found in Chimpanzee, the dorsal interossei are not so dorsally placed as in Man. Moreover, this fact was plainly set forth in the hand of my Chimpanzee, in which parts of the dorsal interossei were so divaricated palmarly as to be positively palmarly, and not at all dorsally, placed. In the lower Monkeys, as Cebus, *Innuus nemestrinus*, and in Anubis, there are really no true dorsal interossei, but two layers of plantar, the more dorsally lying of which we may take, if we please, to represent the dorsal interossei. The more plantarly placed resemble the interossei of the Carnivora, as Church remarks. We, therefore, have an ascending series from that case where the dorsal interossei are plantarly placed (represented by the Cebus and Anubis, the more plantarly placed resembling those of the Carnivora), to the Anthropoid Apes, where these are more dorsal, and thus to Man, where they are more dorsal still. This dorsal migration of the interossei is very interesting."

The Nerves of the Hind-limb of the *Thylacine* and *Cuscus*.

So much stress is now laid upon "nerve supply" in the determination of "muscle homology," that it becomes a matter of importance to add in every way possible to our knowledge of the comparative anatomy of the nervous system. With this end in view I have examined with great care the arrangement of the nerves in the hind-limb of the *Thylacine* and *Cuscus*.

Lumbar plexus.—In both the *Thylacine* and *Cuscus* the anterior primary divisions of the lumbar nerves are six in number, but the part which these play in the formation of the lumbar plexus differs in the two animals. In *Thylacinus* (Pl. V. fig. 5), the plexus is formed by the first four nerves, whilst the fifth and sixth lumbar nerves join to constitute the lumbo-sacral cord. In *Cuscus* (Pl. V. fig. 6) the first lumbar nerve is quite independent of the plexus, and is expended like the last dorsal in the abdominal wall, whilst the plexus is formed by the union of the 2nd, 3rd, and 4th nerves, and the greater part of the fifth nerve. The lumbo-sacral cord in this case is composed of the remaining part of the fifth and the whole of the sixth nerve. In both animals the plexus has the usual looped arrangement.

Branches.—In *Thylacinus* (Pl. V. fig. 5) the branches of the plexus come off in the following manner:—(1) from the 1st lumbar nerve a large branch to the abdominal parietes; (2) from the loop between the 1st and 2nd, two twigs to the abdominal parietes; (3) from the loop between the 2nd and 3rd, the genito-crural nerve (*g.c.*); (4 from the loop between the 3rd and 4th, the external cutaneous nerve (*e.c.*); (5) from the 3rd and 4th, the anterior crural (*a.c.*), and obturator nerves (*o*); (6) from the 2nd, 3rd, and 4th, twigs to the psoas.

In the *Cuscus* (Pl. V. fig. 6) the branches have the following origin:—(1) From the 2nd, a branch to the abdominal parietes; (2) from the 3rd, a long nerve to the abdominal wall, and a small twig to the psoas (*p*); (3) from the loop between the 3rd and 4th, the genito-crural (*g.c*); (4) from the 3rd and 4th, the external cutaneous (*e.c*); (5) from the 3rd, 4th, and 5th, the anterior crural (*a.c*); (6) from the 4th and 5th, the obturator (*o*).

If we exclude the 1st lumbar nerve and enumerate the others from the second backwards, there is a striking resemblance between the lumbar plexus in the *Cuscus* and that in Man, both in its mode of formation and in the manner in which the branches take origin

The three branches which are given off both in *Thylacinus* and *Cuscus* to the abdominal parietes correspond to the ilio-inguinal and ilio-hypogastric in man, and they are distributed to the muscles and skin upon the same plan.

The genito-crural (Pl. V. figs. 5 and 6, *g.c* and Pl. IV. figs 1 and 4, *g.c.n*) proceeds downwards through the psoas parvus to reach the large cremaster, into the deep surface

of which it sinks. In the male it is entirely expended in the supply of this muscle, but in the female *Thylacine* it soon emerges from midst the muscular fibres of the cremaster, and is continued upon the superficial aspect of the muscle through the external abdominal ring, and under cover of the sphincter muscle of the marsupium to the region of the nipples, where it breaks up into a series of fine terminal twigs (Pl. IV. fig. 4, *g.c.n*). These are doubtless for the supply of the mammary gland, which in the specimen I dissected (evidently a young virgin) could not be detected.

The external cutaneous (Pl. V. figs. 5 and 6, *e.c*) is distributed to the skin on the outer aspect of the thigh. It pierces the abdominal wall near the crest of the ilium, and in the *Cuscus* it was observed to give several fine twigs to the panniculus carnosus.

The anterior crural[1] (Pl. IV. fig. 1, *a.c.n*, and Pl. V. figs. 5 and 6, *a.c*) in the *Thylacine* arises in common with the obturator from the 3rd and 4th lumbar nerves, whilst in the *Cuscus* it has an independent origin by two roots from the 3rd, 4th, and 5th nerves. In both it proceeds backwards in the interval between the psoas parvus and magnus, and, entering the thigh, at once breaks up into a large number of muscular and cutaneous branches.

During its course within the abdomen it gives a plentiful supply of twigs to the psoas and iliacus muscles, and in the *Cuscus* a long slender twig (Pl. V. fig. 6, *s*) was observed to spring from it, which pierced the abdominal wall to reach the sartorius. In the thigh muscular branches are distributed to the sartorius, the pectineus, and the various parts of the quadriceps extensor muscle. The cutaneous branches are the long saphenous nerve and three or four twigs to the skin upon the anterior and inner aspects of the thigh.

The long saphenous nerve (Pl. IV. fig. 1, *c.c.n*) is a very constant nerve in all mammals, although it varies very considerably in bulk and in its area of distribution. It descends upon the inner aspect of the thigh and leg in company with the vein of the same name, and dispenses numerous twigs to the skin. In the *Thylacine* its terminal twigs are lost in the integuments over the internal ankle. In the *Cuscus*, however, it is continued downwards in front of the inner maleolus for the supply of the skin on the dorsal aspect of the broad opposable hallux (Pl. VI. fig. 8, 3). Here it is joined by a twig from a special nerve to the hallux (Pl. VI. fig. 8, 4) (derived from the internal popliteal), and breaks up into three filaments; of these one runs along each margin of the digit, whilst the third proceeds along its middle line. On the dorsum of the foot it effects a communication with the musculo-cutaneous nerve.

A glance at the beautiful figures which accompany Ruge's paper[2] upon The Group of

[1] In the Ass, in which the lumbar nerves are six in number, the anterior crural nerve springs from the 3rd, 4th, 5th, and 6th nerves; and in the Fox, in which the lumbar nerves are seven in number, it takes origin from the 4th, 5th, and 6th (Swan's Comparative Anatomy of the Nervous System).

[2] Morphol. Jahrbuch, 1878.—Untersuchung über die Extensorengruppe am Unterschenkel und Fusse der Säugethiere von Dr. Georg Ruge, Heidelberg.

Extensors on the Leg and Foot of Mammalia, will show how variable the long saphenous nerve is in respect to its terminal distribution. In the *Mustela foina, Meles vulgaris, Felis domestica, Cercopithecus,* it ends before it reaches the foot; in the *Ornithorhynchus paradoxus, Didelphys virginiana, Nasua socialis, Felis leo, Inuus cynomolgus, Cebus,* and Orang it reaches the dorsum of the foot, and supplies filaments to the skin of the hallux. In none of these, however, excepting the *Ornithorhynchus,* is its area of supply on the dorsum of the foot so wide as in the *Cuscus.*

The obturator nerve[1] (Pl. V. figs. 5 and 6, *o*, and fig. 4, 1; also Pl. IV. fig. 1, *o.n*) is small in comparison with the corresponding nerve in man. It arises in *Thylacinus* in common with the anterior crural, and in *Cuscus* by two roots from the 4th and 5th lumbar nerves. Its course and distribution is the same in both animals. Quitting the pelvis through the upper part of the thyroid foramen it supplies branches to the obturator externus and the adductors longus and brevis, and ends by sinking into the substance of the gracilis. It gives no twigs to the pectineus or adductor magnus, neither does it divide into a superficial and deep division.

Sacral plexus.—In *Thylacinus* (Pl. V. fig. 5) the sacral plexus is apparently formed entirely by the lumbo-sacral cord, which is prolonged into the gluteal region as the great sciatic nerve (*g'.s*). No communication could be traced between this great nervous trunk and the first sacral nerve. Before quitting the pelvis it gives origin to (1) the superior gluteal (*s.g*); (2) a special branch to the ecto-gluteus (*g.m*); (3) a special nerve to the hamstring muscles (*h*); (4) branches to the pyriformis.

From the 1st sacral nerve the pudic (*p*) and small sciatic nerves (*s.s*) take origin.

In the *Cuscus* the arrangement is quite different (Pl. V. fig. 6). The lumbo-sacral cord is joined by the whole of the 1st sacral nerve, and a small portion of the 2nd sacral nerve, and a large nervous band is thus formed. This divides into two unequal parts, of which the larger is the great sciatic (*g'.s*) whilst the smaller gives origin to (1) a special branch to the ecto-gluteus (*g.m*); (2) the small sciatic (*s.s*); (3) the special nerve to the hamstrings (*h*).

The superior gluteal nerve (*s.g*) arises from the lumbo-sacral cord before it is joined by the sacral nerves, and the pudic (*p*) comes from the 2nd sacral nerve.

Nerves to ecto-gluteus.—The several parts of this muscle (the representatives of the gluteus maximus in man) are supplied differently in the two animals. In *Thylacinus* one large nerve enters the gluteal region through the anterior part of the great sacro-sciatic foramen, and breaks up into branches for the supply of the four constituent parts of the ecto-gluteus (Pl. IV. fig. 5, *g.n*). In *Cuscus* this branch is much smaller in size, because the ecto-gluteus also draws twigs from the small sciatic.

Superior gluteal nerve (Pl. III. fig. 1, *s.g.n*).—After emerging from the pelvis through the great sacro-sciatic foramen, this nerve ramifies between the meso-gluteus and

[1] In the Fox the obturator springs from the 5th and 6th nerves, and in the Ass from the 4th, 5th, and 6th (Swan).

endo-gluteus, and supplies filaments to both. In *Cuscus* a long slender twig can be traced downwards to end in the ecto-gluteus, where it folds round the lower margin of the meso-gluteus to become continuous with the endo-gluteus. The fibres to which this twig is distributed undoubtedly represent the tensor fasciæ femoris.

Small sciatic.—In the *Thylacine* (Pl. IV. fig. 5, *s.s.n*) this is a purely cutaneous nerve, whilst in the *Cuscus* (Pl. III. fig. 1, *s.s.n*) it also contains motor fibres which it dispenses to the ecto-gluteus. Emerging from the pelvis through the great sacro-sciatic foramen in front of the pyriformis it makes its entrance into the gluteal region under cover of the meso-gluteus. It soon appears at the posterior border of this muscle, and then proceeds backwards upon the pyriformis and ischio-femoral muscles covered by the ecto-gluteus. Finally, dipping under the superficial vertebral origin of the biceps muscle it becomes superficial on the back of the thigh, and is distributed to the skin as low down as the upper part of the leg.

Nerve to hamstrings (Pl. III. fig. 1, *h.n*, and Pl. IV. fig. 5, *h.n*).—This is hardly an appropriate name for this nerve, seeing that it has a much wider distribution than to the hamstring muscles, but it is difficult to suggest a better. It is a large nerve, composed entirely of motor fibres. It enters the gluteal region through the great sacro-sciatic foramen, and proceeds backwards upon the endo-gluteus, and under cover of the pyriformis. At the lower border of the latter muscle it gives off a large branch (Pl. III. fig. 1, *g.n*)—the representative of the nerve to the quadratus femoris in man,—and then continues downwards under the ischio-femoral muscle to the under surface of the biceps muscle. Here it breaks up into a large number of branches for the supply of the biceps and its various accessory parts, the semitendinosus and the semi-membranosus.

In the *Cuscus* the nerve to the quadratus femoris sinks into the substance of the gemelli muscles, and is continued backwards through their muscular fibres. Issuing from the midst of the gemellus inferior, it is carried downwards under cover of the quadratus femoris to the adductor magnus. In this course it supplies twigs to the gemelli, quadratus femoris, and probably to the obturatus internus, whilst it ends in the adductor magnus, and constitutes its sole nerve of supply.

In the *Thylacine* the distribution of the nerve to the quadratus is precisely similar to that in the *Cuscus*, but its relations to the gemelli muscles are somewhat different. Each gemellus consists of a superficial and deep part, and the nerve in passing backwards passes between the two portions of the superior muscle, and then under cover of the obturator internus and both portions of the inferior gemellus.

In *Thylacinus* and *Cuscus*, therefore, the adductor magnus is associated by its nervous supply with the quadratus femoris, and it draws branches from neither of its usual sources, viz., the great sciatic and the obturator nerves. The advocates for the theory that nerve-supply points infallibly to the homology of a muscle will find this a difficult fact to solve. Of course it might be explained by supposing that the adductor magnus

is a compound muscle, consisting of a part belonging to the adductor group, which in this case has fused with the large adductor brevis, and a part derived from the flexor group, which in the present instance is independent, and receives its nerve fibres from the same source, but through a different nerve-strand, viz., the nerve to the quadratus.

The adducting group of muscles holds an intermediate position in the thigh, and in Man it seems to merge in front with the extensors, and behind with the flexors. The nerve supply points to this. Thus the pectineus is furnished with twigs from the obturator and anterior crural nerves, whilst the adductor magnus is supplied by the obturator and great sciatic nerves.

Pudic (Pl. III. fig. 1, *p.n*, and Pl. IV. fig. 5, *p.n*).—This is a small nerve which runs backwards under cover of the pyriformis muscle, and then through the small sciatic notch to the perineum. In the gluteal region of the *Thylacine* it gives a small twig to the posterior of the two vertebral portions of the biceps, whilst in *Cuscus* it receives a communicating twig from the nerve to the hamstrings (Pl. V. fig. 6, *p*).

Great sciatic (Pl. III. fig. 1, and Pl. IV. fig. 5, *g.s.n*).—The great sciatic enters the gluteal region under cover of the meso-gluteus, and proceeds backwards upon the pyriformis, obturator internus and gemelli, and the ischio-femoral muscle, to the under surface of the biceps. Half-way down the thigh it ends by dividing in three, viz.:—(1) internal popliteal; (2) external popliteal; (3) external saphenous. It gives off no collateral branches.

External saphenous (Pl. V. fig. 2, 1).—This large nerve proceeds downwards under cover of the biceps to the outer back aspect of the leg, along which it runs to the external maleolus. It is continued behind this bony prominence to the outer margin of the pes, where it ends as the fibular dorsal collateral branch of the little toe (Pl. VI. fig. 8, 1). It supplies (*a*) muscular, (*b*) communicating, and (*c*) cutaneous twigs.

The muscular branches are different in the two animals. In *Thylacinus* it sends a twig to the lower part of the biceps. In *Cuscus* it gives a branch to the inner head of the gastrocnemius, and another to the fibular part of the vertebral portion of the biceps.

The communicating branches are—(1) a strongly marked twig, present in both animals, which passes inwards under cover of the tendo-Achillis and the tendon of the plantaris to join the external plantar nerve (Pl. V. fig. 2, 2); (2) in the *Cuscus* a twig to the musculo-cutaneous nerve on the dorsum of the foot (Pl. VI. fig. 8).

The cutaneous twigs are very numerous, and supply the skin over the outer aspect of the leg and foot.

Internal popliteal (Pl. VI. fig. 8, 4).—This is the largest of the three terminal divisions of the great sciatic. In *Thylacinus* it sends off behind the knee joint, and between the heads of the gastrocnemius a large number of muscular branches to the superficial and deep muscles on the back of the leg, and then divides into the external and internal

plantar nerves. The gastrocnemius receives two of its muscular branches—one to each of its heads, whilst the popliteus appropriates no less than three. These enter its upper, middle, and lower portions respectively. The second of these proceeds downwards in the interval between the tibialis posticus and flexor longus digitorum, and the third between the tibialis posticus and the flexor longus hallucis.

In the right leg the plantaris was supplied by two twigs from the external plantar nerve.

In *Cuscus* the same muscular branches (Pl. V. fig. 2, 5) are given by the internal popliteal, but the nerve ends by dividing into three, viz.:—(1) a nerve to the hallux (7); (2) internal plantar (6); (3) external plantar (3).

The *nerve of the hallux* is present only in *Cuscus*. It runs downwards alongside the internal plantar nerve between the superficial and deep muscles on the back of the leg. Near the ankle it diverges inwards, leaves the internal plantar nerve, and is distributed to the hallux by a dorsal and a plantar branch (Pl. VI. fig. 8, 4, and fig. 5, 1). The dorsal branch joins the inner of the three terminal twigs of the internal saphenous, and is distributed upon the tibial margin of the digit; the plantar branch pierces the inner edge of the abductor hallucis which it supplies, and then forms the inner collateral plantar twig for the hallux (Pl. VI. fig. 7, 1). This branch in one limb was joined by a filament from the internal plantar nerve.

Internal plantar nerve.—The internal plantar nerve runs down the back of the leg between the superficial and deep muscles, and enters the sole by passing behind the internal maleolus.

In *Thylacinus* it now proceeds along the inner margin of the flexor brevis digitorum, and, sinking under cover of the plantar fascia, divides into three digital branches, which are distributed in the following manner (Pl. VI. fig. 4, 2):—(1) the first goes to the tibial side of the index; (2) the second, which is reinforced by a long slender twig from the deep division of the external plantar, bifurcates to supply the adjacent margins of the index and medius; (3) the third divides and supplies the contiguous margins of the medius and annularis. From the main trunk several small twigs are given to the flexor brevis digitorum, whilst from the digital nerves no fewer than ten branches are supplied to the plantar pad.

In *Cuscus* the internal plantar at the ankle sends a recurrent branch (Pl. V. fig. 2, 8) to the flexor brevis digitorum, and a communicating and reinforcing twig to the plantar portion of the nerve to the hallux. It then enters the sole by passing under cover of the plantar cartilage, and, after sending branches to the flexor brevis hallucis, divides into three digital branches, which have the following distribution:—(1) the first bifurcates to supply the adjacent sides of the hallux and index; (2) the second divides for the supply of the contiguous and adherent sides of the index and medius; and (3) the third goes to the adjacent sides of the medius and the large annularis, and in addition communicates with the inner digital branch of the external plantar (Pl. VI. fig. 7, 2).

External plantar nerve (Pl. V. fig. 2, 1).—This nerve proceeds down the back of the leg in close company with the internal plantar, and near the heel it is joined by the large reinforcing branch from the external saphenous. The further course of the external plantar differs so much in the two animals that a separate description for each becomes necessary.

In *Thylacinus* (Pl. VI. fig. 1, 1, and fig. 4, 1) it lies close against the os calcis, and entering the sole diverges to the outer margin of the foot under cover of the flexor brevis digitorum. Here it gives twigs to the abductor ossis metatarsi minimi digiti and the long abductor minimi digiti, and then divides into (*a*) a superficial, and (*b*) a deep portion.

The superficial division is a purely cutaneous nerve, and almost immediately divides into two digital branches, viz.:—one to the fibular side of the minimus (Fig. 1, 4), and a second which bifurcates to supply the adjacent margins of the minimus and annularis (3). The twig which goes to the tibial side of the minimus is reinforced by a slender filament from the deep division of the external plantar nerve.

The deep division of the external plantar (Fig. 1, 2) turns inwards, and, disappearing from view under cover of the great flexor tendon, insinuates itself between the plantar or adductor, and the intermediate or flexor groups of intrinsic muscles, where it divides into an outer and an inner branch. The external branch proceeds downwards, and after giving twigs to the short abductor minimi digiti, the flexor brevis minimi digiti and the fourth dorsal interosseous muscle (*i.e.*, the abductor annularis), it emerges from under cover of the adductor minimi digiti in the cleft between the minimus and annularis, and joins the tibial digital nerve to the minimus. The internal branch is carried transversely across the sole upon the intermediate muscles, and gradually exhausts itself in the supply of the other intrinsic muscles of the foot. It also effects a communication by means of a long slender filament with the digital nerve from the internal plantar to the adjacent margins of the index and medius.

In *Cuscus* (Pl. VI. fig. 5, 2, and fig 7, 3) the external plantar nerve gains the sole by passing under cover of the ligament which binds the plantar cartilage to the tuber of the os calcis, and immediately divides into a superficial and a deep division.

The superficial branch proceeds outwards and downwards over the abductors of the minimus, and ends as the fibular plantar nerve of this digit.

The deep branch supplies twigs to the three abductors and the opponens of the minimus, and passing under cover of the last muscle reaches the interval between the plantar and intermediate muscles. Here it divides as in the *Thylacine* into an outer and inner branch.

The external branch emerges from under cover of the adductor minimi digiti, and divides to supply the adjacent sides of the minimus and annularis. The internal branch ends by supplying twigs to all the intrinsic muscles, with the exception of (1) the abductors

and opponens of the minimus; (2) the flexor brevis hallucis, which receives its twigs from the internal plantar; and (3) the abductor hallucis, which is supplied by the nerve to the hallux.

External popliteal (Pl. V. fig. 3, 1).—In *Thylacinus* this nerve gives off no branches in the thigh, but diverging outwards pierces the outer head of the gastrocnemius, and at once divides into its superficial and deep portions, *i.e.*, the musculo-cutaneous and anterior tibial.

The *musculo-cutaneous*, unlike the corresponding nerve in Man, is intended for the supply of skin alone. It proceeds downwards upon the anterior aspect of the leg, dispensing filaments as it goes, and ultimately it reaches the dorsum of the foot where it ends in four branches, which have the following distribution:—(1) the first (counting from the inner margin of the foot) constitutes the tibial branch upon the dorsal aspect of the index; (2) the second joins the fibular dorsal branch of the index, which is derived from the anterior tibial; (3) the third joins the fibular dorsal branch of the medius, which also comes from the anterior tibial; (4) whilst the fourth bifurcates to supply the adjacent margins of the minimus and annularis (Pl. VI. fig. 3, 2).

The *anterior tibial* nerve proceeds forwards between the two heads of the peroneus longus, and then pierces the peroneus brevis and extensor communis digitorum to reach the interval between it and the tibialis anticus. It is now continued downwards upon the interosseous membrane, and, passing under cover of the upper annular ligament, reaches the dorsum of the foot. Here it ends by dividing into two dorsal digital branches. These are distributed thus:—(1) the first divides to supply the adjacent sides of the index and medius, whilst (2) the second bifurcates to end upon the contiguous margins of the medius and annularis (Pl. VI. fig. 3, 1).

Muscular branches.—Between the heads of the peroneus longus the anterior tibial gives off a great number of muscular branches which go to the two heads of the peroneus longus, the peroneus brevis, the extensor brevis minimi digiti, upon which the nerve lies, the common extensor, and the tibialis anticus. A long slender twig also proceeds downwards to supply the two lower portions of the extensor brevis. Whilst the nerve lies between the tibialis anticus and the common extensor it gives additional twigs to the inner part of the latter, which might be considered as an indication that the absent extensor longus hallucis is fused with the extensor communis digitorum.

In the *Cuscus* the external popliteal does not pierce the outer head of the gastrocnemius. At the head of the fibula it divides into the musculo-cutaneous and anterior tibial (Pl. V. fig. 3, 1).

The musculo-cutaneous, in passing down the leg, supplies a few twigs to the biceps, under cover of which it runs. No branches, however, are given to the peroneal muscles. On the dorsum of the foot it breaks up into four branches which supply dorsal digital

twigs to both sides of all the toes, with the exception of the hallux and the outer margin of the minimus (Pl. VI. fig. 8, 2).

The anterior tibial (Pl. V. fig. 3, 2) in the *Cuscus* is a purely motor nerve, and differs from that in the *Thylacine* by ending on the dorsum of the foot and supplying the extensor brevis of the index and medius, which in this animal has wandered downwards so as to lie upon the dorsum of the foot.[1] In the front of the leg the nerve lies between the extensor longus hallucis and the tibialis anticus.

The comparative anatomy of the external popliteal nerve has recently received special attention from Dr. Georg Ruge in his elaborate memoir upon the extensor muscles of the leg and foot in Mammalia. He examined three marsupials, viz., the *Didelyphys virginiana*, the *Didelyphys cancrivora*, and the *Dasyurus hallucinatus*. In all these the general arrangement of the nerve was very similar to that which I have described as existing in the *Thylacine* and *Cuscus*. There seems to be, however, a great variation in the relative distribution of the musculo-cutaneous and anterior tibial to the skin on the dorsum of the foot. In *Dasyurus* as in *Cuscus* the anterior tibial is purely motor, and although it reaches the dorsum of the foot it gives no branches to the integument. In *Didelyphys*, as in the *Thylacine*, the anterior tibial combines a large proportion of sensory fibres with its motor fibres. Thus in *Didelyphys virginiana* it supplies the adjacent sides of the index and medius, and also the fibular side of the hallux, whilst in *Didelyphys cancrivora* it sends twigs to both sides of the index and the tibial side of the medius. This combination of fibres in the anterior tibial, as Ruge shows, seems to be the more usual disposition throughout Mammalia generally. In some animals, indeed (as for instance the *Ateles*), the anterior tibial appears almost to supplant the musculo-cutaneous as the nerve of supply to the dorsal aspect of the digits.

Ruge is a firm believer in the invariable and immutable relationship between "nerve-supply" and "muscle-homology."

Perhaps, however, the strongest evidence of any against the immutability of nerve-supply is provided by Dr. Ruge himself.[2] Thus in the *Ornithorhynchus* he finds the tibialis anticus and the inner portion of the extensor longus hallucis supplied by a branch from the anterior crural, which is prolonged downwards to its destination over the external condyle of the femur. To account for this, he assumes that "the internal part of the extensor longus hallucis and the tibialis anticus are not homologous to the similarly named muscles" in other animals, but "belong rather to the extensor group of the thigh." He believes that the fibres which are supplied by the anterior crural nerve are gradually abolished, and that their place is taken by the external muscles of the leg.

[1] In the *Vulpine phalanger* the anterior tibial on the dorsum of the foot is not expended entirely upon the extensor brevis, but is continued onwards to supply the skin upon the inner side of the index. It likewise sends many twigs to the integument in the interval between this digit and the hallux, and it communicates with the musculo-cutaneous.

[2] *Loc. cit.*

With the first part of this hypothesis I am inclined to agree, viz., that the innervation of these muscles points to their probable derivation from the extensor muscles of the thigh; but I cannot accept the second part of the theory, that the muscles thus derived are replaced by others similarly situated and similarly attached. It is much more reasonable to suppose that the distribution of the peroneal nerve is gradually extended so as to include these muscles; that, in fact, the peroneal nerve invades the territory of the anterior crural in the same manner as we have seen the external plantar nerve encroach upon the domain of the internal plantar.

In the nervous arrangements in the hind-limb of the *Thylacine* and *Cuscus* there are facts which also require explanation if we are to accept these views as to the relation of nerve-supply to muscle-homology. Thus the biceps and its accessory parts receives twigs from (1) the pudic; (2) the nerve to the ham-strings; (3) the external saphenous; (4) the musculo-cutaneous: the adductor magnus is entirely supplied by the nerve to the quadratus femoris; and the inner head of the gastrocnemius in the *Cuscus* receives a twig from the external saphenous. If the source in the spinal cord from which the nerve fibres are derived is invariably the same, it is at least certain that the nerve-strands through which the fibres reach the muscle are often very different.

From the facts that I have brought forward, I think that we are entitled to conclude that the doctrine of the invariable relation between nerve-supply and muscle-homology is an erroneous one, and contrary to existing fact.[1] The value of this feature, however, in the determination of the history of a muscle cannot be overrated. Indeed, it is hardly equalled in importance by the "insertion."

Lastly, I consider that it is not at all unlikely—indeed, that it is highly probable—that the source in the brain or spinal cord from which the nerve fibres, destined for the supply of a certain muscle, are derived is invariably the same. Of this, however, we have little proof. It is a matter of certainty, as we have seen, that these fibres may adopt different nerve-strands in order to reach the muscle. Even in the human body great numbers of examples of this may be quoted. Thus the long buccal nerve has been

[1] Since the above was written, after, indeed, it was published in the form of an abstract (Relation of Nerve-Supply to Muscle-Homology, Jour. Anat. and Phys., vol. xvi.), a highly important paper by Dr. Hans Gadow has appeared, entitled "Beiträge zur Myologie der hinteren Extremität der Reptilien" (Morpholog. Jahrbuch, 1881). It is very satisfactory to find that, although a pupil of the Heidelberg school from which the doctrine of the immutability of nerve-supply originally emanated, he has arrived at results very similar to my own. Working, however, at lower forms than those offered by the Mammalian order he has had a better opportunity afforded him of clearing up the question. In my investigations I have been led to believe that wherever a muscle possessed a double nerve-supply this pointed to the amalgamation of two originally distinct muscles. Dr. Gadow, however, has proved that this interpretation only applies to comparatively few cases. In mammals it is rare to meet with a muscle which draws its nerve-supply from two different sources; in Man the adductor magnus, the pectineus and brachialis anticus are the best examples of this, and we have met with several other instances in the lower members of the group. In the lower animals, however, it is an extremely common occurrence, and Dr. Gadow has shown that the percentage of double-nerved muscles diminishes as we ascend the animal series from the Reptilia, through the birds, up to mammals; whilst at the same time the number of muscles increases. He concludes, therefore, that in the majority of cases double-nerved muscles show the original state, and that these muscles afterwards may become single-nerved muscles by splitting up into two or more separate factors.

observed by Professor Turner to proceed from the superior maxillary division of the fifth ;[1] again, every demonstrator of anatomy has observed the descendens noni taking its origin from the vagus instead of the ninth nerve ; and the frequency of the accessory obturator and the accessory phrenic nerves is a fact of common knowledge. The Cetacea afford us a very striking illustration. The absence of functional hind-limbs and the massing of the muscles in the posterior part of the animal into four great columns, which are situated one upon each aspect of the spine, give rise to a corresponding adaptation of the nerves. Thus we find that the lumbo-caudal nerves, after giving off branches to the genitals and the abdominal wall, arrange themselves in four nerve-cords, which extend backwards upon the vertebræ to the tail. Each cord is developed in relation to one of the four fleshy columns.[2] The arrangement is peculiar to the Cetacea, and probably also the Sirenia.

Thoracic Viscera.

The thoracic viscera were examined in each specimen that was put into my hands, viz., in the *Thylacine*, the *Dasyure* (*Dasyurus viverrinus*), *Cuscus*, *Vulpine phalanger* and *Phascogale*. I now propose giving a sketch of the peculiarities which were noted.

Pericardium.

In *Thylacinus* the pericardium is oval or fusiform in shape—considerably narrower behind than in front. Posteriorly the fibrous layer presents a slight attachment to the diaphragm, whilst anteriorly it is lost upon the coats of the aorta and great vessels. Two indefinite fibrous bands, the sterno-pericardiac ligaments, bind its lower surface to the upper aspect of the sternum. In addition to the usual vessels the fibrous pericardium is pierced, in front of the root of the left lung, by the left superior vena cava. The serous pericardium reaches the surface of the heart in the usual manner. There is, however, no trace of the vestigial fold of Marshall.

In the *Dasyure*, *Phalanger*, and the *Phascogale*, the fibrous pericardium presents no direct attachment to the anterior surface of the diaphragm. In *Cuscus*, however, a distinct fibrous band passed between these structures. This was not observed in the other animals. In other respects the pericardium of each agrees with that of the *Thylacine*.

Heart.

Owen considers the Marsupial heart to be distinguished by three leading peculiarities, viz., (1) a bifurcation of the appendix of the right auricle into two angular processes which embrace the root of the aorta; (2) the absence of the annulus and fossa ovalis—a condition which doubtless points to the short intra-uterine life of the fœtus, and (3) the absence of the terminal aperture, in the right auricle, of the "coronary

[1] Journal of Anat. and Phys., vol. i. ; and Proc. Royal Soc. London, 1868.

[2] *Vide* Cunningham, Spinal Nervous System of Porpoise and Dolphin, Journal of Anatomy and Physiology, vol. xi.

vein."[1] It appears to me that only one of these features can be considered as being a universal distinction in the Marsupial heart, and that is the total absence of any land-mark pointing back the early communication which exists between the auricles. In *Thylacine* and *Dasyure*[2] there is not the slightest approach or tendency to a cleavage or bifurcation of the appendix of the right auricle, and in all the animals I examined the great cardiac vein (*i.e.*, the vein which in the human heart expands into the coronary sinus) entered the right auricle by an independent opening placed in the upper part of the auricle by the side of the orifice of the right anterior vena cava.

In *Thylacinus* (Pl. IX. fig. 1) the heart is narrow, elongated and pointed. The *right auricle* is very capacious, and its appendix, whilst it shows no indication of bifurcation, is peculiar on account of its great breadth. On opening into the cavity of this auricle we notice that the walls of the appendix alone present musculi pectinati. The walls of the atrium are perfectly smooth and even. In addition to the minute apertures of the venæ Thebesii, and the small mouths of a few anterior cardiac veins which open directly into the auricle, there are four large venous openings—two in front, and two behind. Those in front are the orifice of the right anterior vena cava (which has the same position as that of the superior vena cava in man), and the orifice of the great cardiac vein which lies at a slightly lower level, and to its inner side. The latter presents a gaping mouth towards the cavity, and both are totally destitute of valves. The two posterior openings are (1) that of the posterior vena cana which has the usual situation, and (2) the opening of the left anterior vena cava which is placed between the orifice of the posterior vena cava, and the auriculo-ventricular opening,—it occupies, therefore, the same position as the coronary aperture in the human heart. The auriculo-ventricular opening readily allows two fingers to be passed through it into the cavity of the right ventricle.

Right ventricle.—The cavity of the right ventricle falls short of the apex of the heart by fully an inch and a half. The conus arteriosus is very pronounced. In the interior of the ventricle the columnæ carneæ are scarce and are altogether absent in the conus arteriosus, and at the apex of the cavity. The musculi papillares are disposed in two groups, viz., one upon the septum near its anterior margin, and the other upon the anterior wall of the ventricle near the right sharp margin of the heart. In connection with each there is a moderator band. That passing from the base of the septal muscle to the anterior wall is very delicate, whilst the other, which stretches between the base of the anterior muscle and the septum, is remarkably strong. Indeed, we might look upon the anterior musculus papillaris as arising by two equal parts, one from the septum, and the other from the anterior wall.

[1] Notes on the Anatomy of the Wombat (Proc. Zool. Soc. 1836, p. 51); Comparative Anatomy and Physiology of Vertebrates, vol. iii. p. 517; Cyclopædia of Anatomy and Physiology (Marsupialia), vol. iii. p. 306.

[2] In his paper upon *Dasyurus macrurus* (Proc. Zool. Soc., 1835, p. 8) he makes no reference to a bifurcated condition of the right auricle. He only says—"The right auricle rose high above the left. Both auricles had smooth short appendices."

The right auriculo-ventricular opening is guarded by a valve formed of five triangular membranous cusps. Three of these lie anteriorly against the anterior wall; one lies to the right in relation to the sharp margin of the heart; whilst the fifth is placed posteriorly against the septum. United at their bases, the five segments constitute an annular membrane by which they are attached around the opening. The three anterior cusps are very small and of equal size; the posterior segment is very large; whilst the right segment is intermediate in size.

The orifice of the pulmonary artery is guarded by the usual three semi-lunar valves.

Left auricle.—The appendix of the left auricle is filled by a very beautiful arrangement of musculi pectinati. These intersect one another, and pass between the walls so closely that the cavity is broken up into a sponge-like texture. There are no musculi pectinati on the walls of the atrium. On the posterior wall there are three venous openings.

Left ventricle.—The cavity of the left ventricle is very narrow and of a conical shape. The fleshy columns are very strongly marked, some, indeed, stretching as thick prominent ridges from the ariculo-ventricular orifice to the apex. The musculi papillares are two in number, and very powerful. The auriculo-ventricular valve is bicuspid, and the segments are placed obliquely as in Man. The orifice of the aorta is provided with the usual three semilunar segments.

Turning now to the *Dasyurus viverrinus* we find that the right auricle of the heart is in every respect the same as in the *Thylacine*. There is no bifurcation of its appendix, and its interior presents the same appearance.

In the right ventricle what strikes one most is the extreme smoothness of its walls. There is hardly a trace of columnæ carneæ except where the septum joins the anterior wall; here we notice a series of "moderator bands" passing from the septum to the anterior wall of the ventricle. The musculi papillares are three in number, and they all spring from the septum. The right auriculo-ventricular valve is peculiar. In front and at the sides of the orifice there is simply a membranous curtain of uniform length hanging down into the cavity, and to this all the chordæ tendineæ from the three musculi papillares are attached. Behind, there is a broad separate segment which is bound directly to the septum by chordæ tendineæ.

The left side of the heart in the *Dasyure* is the same as in *Thylacine*.

In *Cuscus* the heart has the same elongated narrow appearance as in *Thylacinus*. The right auricular appendage, however, presents a deep crescentic notch on its inner free margin into which is received the first part of the aortic arch. So deep is this notch that the aorta is almost completely surrounded by the appendix, and the posterior or upper cornu appears in the internal between the pulmonary artery and the aorta. The left auricular appendage shows no notching, and stretches inwards for a considerable distance in front of the conus arteriosus and the pulmonary artery in the form of a narrow tongue-like process.

Right auricle.—The cavity of the right auricle presents the same characters as those noticed in *Thylacine* and *Dasyure*. The opening of the great cardiac vein, however, is very difficult to find, as it is hidden by musculi pectinati.

Right ventricle.—The cavity of the right ventricle shows several points of difference. The columnæ carneæ are confined almost entirely to the anterior wall. The musculi papillares are two in number, and both spring from the septum. They are long and slender, and one is situated near the anterior interventricular furrow, whilst the other takes origin close to the right sharp margin of the heart. A complete chain of "moderator bands" extends downwards from the conus anteriosus to the apex of the cavity, and binds the anterior wall firmly to the septum. Those which are highest are so large that they even exceed in size the musculi papillares, but they gradually diminish as they are traced downwards to the apex.

The right auriculo-ventricular valve presents four separate membranous segments. These cusps are arranged so that two are placed anteriorly, one to the right, and the fourth, much larger than the others, posteriorly against the septum. The first three of these are connected by chordæ tendineæ, with the musculi papillares; the large posterior cusp is bound down by short, strong tendinous cords which take origin from the septum. It therefore possesses a very limited range of movement.

Left auricle.—The cavity of the left auricle differs from that in *Thylacine*, in having its appendicular walls smooth except towards its free margin, where it shows the reticular arrangement of musculi pectinati.

Left ventricle.—In the left ventricle, the columnæ carneæ are something marvellous in their intricacy and delicacy.

The heart of the *Vulpine phalanger* closely resembles that of the *Cuscus*. The notching of the right auricular appendage is quite as strongly marked, and the only points of difference are found in the right ventricle. Here there are four musculi papillares, all of which spring from the septum and all of which are connected with the three small cusps of the right auriculo-ventricular opening. The large posterior cusp, as in *Cuscus*, is bound directly by chordæ tendineæ to the septum. Further, the moderator bands are neither so distinct nor so numerous.

In the *Phascogale* we note the following points:—(1) the right auricular appendage shows a slight trace of notching, but this has no relation to the root of the aorta; (2) a slight notching of the left auricular appendage is also observable; (3) the musculi papillares are two in number in the right ventricle, and both arise from the septum.

It would appear, therefore, that the distinguishing features of the marsupial heart are two in number, viz.—(1) the absence of all trace of an annulus ovalis and a fossa ovalis, and (2) the peculiar position in the right auricle of the orifice of the great cardiac vein. The notching of the right auricular appendix cannot be regarded as a universal distinction, but when it is present it is a feature of great prominence. It is very clearly figured

by Professor Owen, in his great work upon Comparative Anatomy, in the heart of the Kangaroo and of the Wombat (p. 518, figs. 401 and 402, *a.a*).

Aorta.

In all the animals examined, the aorta describes a very perfect and uniform curve over the root of the left lung. It reaches the spine opposite the lower border of the fourth dorsal vertebra, and then turns backwards.

Except in the case of the *Thylacine* and *Phascogale*, the other animals differ considerably in the manner in which the great vessels arise from the summit of the aortic arch. They all agree, however, in so far that the left subclavian artery has a separate and independent origin from the aortic arch before it turns upwards and backwards to

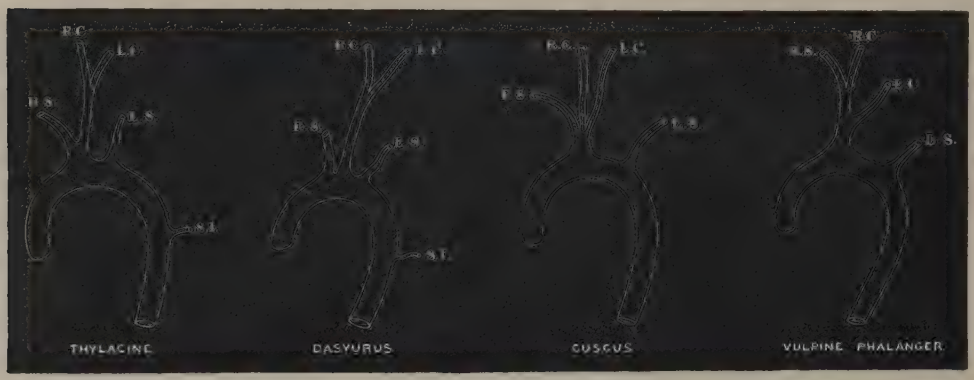


FIG. 4.—Aortic Arch in Thylacine, Dasyurus, Cuscus, and Vulpine phalanger.

R.S. Right subclavian.
R.C. Right common carotid.
L.C. Left common carotid.
L.S. Left subclavian.
S.I. Superior intercostal.

reach the spine. In *Thylacine* and *Phascogale*, the other vessels spring by a short wide trunk from the arch. This very soon gives off the right subclavian artery, and then, continuing forwards for some distance upon the trachea, it finally divides into the two common carotid arteries. In the *Dasyure* the two subclavian arteries come off separately and between them a trunk takes origin, which, after passing forwards upon the trachea for nearly an inch, divides into the two carotids. In the *Dasyurus macrurus*, the great vessels of the aortic arch come off in the same manner as in the *Thylacine*.[1] In the *Cuscus* two vessels proceed from the summit of the aortic arch, viz., the left subclavian and a short wide trunk which very soon breaks up into the two common carotids and the right subclavian. In the *Vulpine phalanger* the same primary vessels

[1] Professor Owen, Notes of a Dissection of a Long-tailed *Dasyurus*, Proc. Zool. Soc., 1835, p. 7.

take origin, but the short wide trunk divides differently; it first gives off the left common carotid artery, and then proceeding onwards for a short distance, divides (like the innominate in man) into a right subclavian, and a right common carotid.

Considerable variation, therefore, is exhibited by Marsupials in the mode of origin of the carotid and right subclavian trunks. The separate origin of the left subclavian is almost universal throughout the group. Mr. Forbes, Prosector to the Zoological Gardens in London, mentions one member of the order (viz., *Belideus breviceps*[1]) in which all the vessels arise from one common trunk or anterior aorta.

The coronary arteries in all the specimens were two in number, and in all the left was much larger than the right. Their openings in the aorta were distinctly above the level of the free margins of the valve segments.

In the *Thylacine* and *Dasyure* the superior intercostal artery of each side springs directly from the aorta at the point where it first touches the spine. This vessel lies in series with the other intercostal arteries, but differs from them in being about three times as large. It runs forwards, and after supplying twigs to the three anterior intercostal spaces it disappears by passing upwards to the dorsal region between necks of the third and fourth ribs. Gaining the superior aspect of the vertebral column, it proceeds forwards between the splenius and semi-spinalis muscles. It can be traced as far as the occipital region.[2]

Pulmonary artery.

The only point to be noted in connection with this vessel is that in none of the animals examined by me was there the slightest vestige of an obliterated ductus arteriosus to be discovered.

Great veins of the heart.

As usual in Marsupials each animal possesses three great caval veins, viz.—(1) a right anterior vena cava, (2) a left anterior vena cava, and (3) a posterior vena cava.[3]

The right anterior vena cava has the same position, relations, and manner of ending as the superior vena cava in man. It pierces the pericardium on the inferior aspect of the root of the right lung and opens into the anterior part of the right auricle.

The left anterior vena cava retains its embryonic course and, piercing the pericardium on the inferior aspect of the root of the left lung, it turns to the right, on the posterior aspect of the heart, in the auriculo-ventricular groove. Here it occupies the same position

[1] Mr. W. A. Forbes, on the Koala, Proc. Zool. Soc., January 1881, p. 189.

[2] In Professor Owen's celebrated article on the Marsupialia in the Cyclopædia of Anatomy and Physiology, the author states that the brachial artery in *Thylacinus* passes over the internal condyle of the humerus, impressing it with a more or less deep groove. In both of my specimens the artery along with its accompanying veins passed through the supra-condyloid foramen.

[3] In the *Belideus breviceps* there appears to be only one anterior vena cava. *Vide* Mr. Forbes' paper on the Koala, Proc. Zool. Soc., 1881, p. 188.

as the coronary sinus of man, and, like it, opens into the posterior part of the right auricle close to the orifice of the posterior vena cava. Towards its termination it is covered by a thin stratum of muscular fibres derived from the muscular wall of the heart.

The posterior vena cava has the usual mode of termination.

The pulmonary veins are two in number on each side.

Veins of the thoracic parietes.

In the *Thylacine* the vena azygos runs forward upon the right side of the vertebral column, and drains the blood from all the intercostal spaces, with the exception of the anterior three upon both sides. It ends by hooking downwards above the root of the right lung, and joining the right anterior vena cava. The three

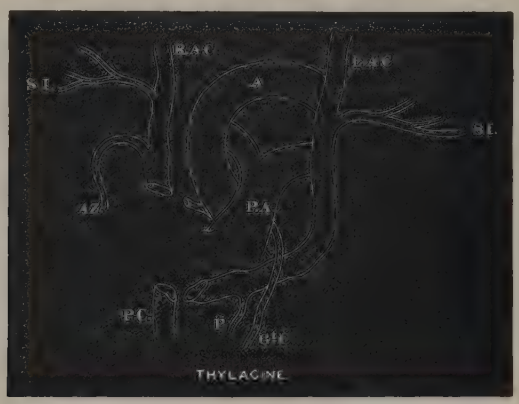


FIG. 5.—Diagram of the veins opening into the right auricle of the heart.

AZ.	Vena azygos major.	Gt^{r} C.	Great cardiac vein.
S.I.	Superior intercostal (right).	P.	Posterior cardiac vein.
R.A.C.	Right anterior vena cava.	P.C.	Posterior vena cava.
L.A.C.	Left anterior vena cava.	A.	Aorta.
S.I.	Superior intercostal vein (left).	P.A.	Pulmonary artery.

anterior intercostal veins of the right side join to form one trunk, which pours its blood into the right anterior vena cava whilst the corresponding veins of the opposite side likewise unite to open into the left anterior vena cava.

In the *Cuscus*, *Dasyure*, *Vulpine phalanger*, and *Phascogale* there is also a single azygos vein; this, however, runs forward upon the left side of the spine. It receives all the blood from the intercostal spaces of its own side, and all the intercostal veins of the right side with the exception of the anterior three. It hooks over the root of the left lung, and joins the left anterior vena cava. The anterior three intercostal veins of the right side unite to pour their blood into the right anterior vena cava.

Cardiac veins.

The cardiac veins were very carefully followed out in the heart of the *Thylacine*. An opening was made into the larger veins, and then the whole cardiac venous system was inflated by a blow-pipe. In this way the vessels could be traced with great precision.

The cardiac veins may be divided into an anterior and a posterior group.

The posterior cardiac veins open into the left anterior vena cava as it lies in the groove between the left auricle and left ventricle. One of these veins is much larger than the others. It begins at the apex (usually upon the anterior surface) and ascends in the posterior interventricular furrow to join the left caval vein close to its termination.

The anterior cardiac veins consist of—(1) some small twigs ascending upon the anterior surface of the right ventricle to open independently into the right auricle, and (2) the great cardiac vein—a vein which is always so conspicuous in the Mammalian heart.

The great cardiac vein takes origin near the apex of the heart. It ascends in the anterior interventricular furrow, and receives numerous tributaries, so that when it reaches the auriculo-ventricular groove it has attained a very considerable magnitude. So far its course agrees with that seen in other Mammals; now, however, instead of winding round the left margin of the heart to join the left anterior vena cava, it deviates to the right, passes behind the pulmonary artery and the aorta, and opens into the upper part of the right auricle, close to the entrance of the right anterior vena cava (Fig. 5). As it lies behind the aorta and pulmonary artery it expands somewhat, and some of the muscular fibres of the heart are thrown over it.[1]

Owing to the small size of the heart in the other animals examined these points could not be made out with the same precision. In all, however, no cardiac veins joined the left anterior vena cava except those from the posterior surface of the heart; in all a small venous opening was noticed in the right auricle close to that of the right anterior vena cava; and in the *Dasyure* and *Cuscus* a fine probe introduced into this passed along a venous channel which lay behind the aorta and pulmonary artery. From these facts I conclude that they all present the same arrangement of cardiac veins.

Owen, in the third volume of his work upon Comparative Anatomy and Physiology, states that "the opening of the left precaval is close to that of the postcaval in a position analogous to that of the coronary vein in man, which here opens into the left precaval." The coronary vein which he thus refers to is, no doubt, the large posterior cardiac vein which ascends in the posterior interventricular furrow. I cannot, however, understand a remark made by Mr. Forbes[2] in his paper upon the Visceral Anatomy of the Koala, viz., that "there is apparently only a single opening for the coronary veins, just at the entrance of the inferior cava into the auricle." Writing upon the same animal

[1] It is interesting to note that at the point where this vein opens into the right auricle there is almost invariably in the human heart the minute orifice of a vein of Thebesius.

[2] Proc. Zool. Soc., 1881.

Mr. Martin states that "six coronary veins entered the right auricle round its junctional margin with the ventricle."[1] These were undoubtedly the small cardiac veins which ascend upon the anterior wall of the right ventricle.

Mr. Marshall[2] in his memoir upon the development of the great anterior veins divides mammals into groups, according to the manner in which these veins are arranged. In the first group, which consists of those animals in which the right and left anterior venæ cavæ persist, and in which the great coronary and other veins in its course join the left anterior vena cava, he places the Marsupials. If, however, the arrangement of the coronary veins, which was so evident in the *Thylacine* is general through Marsupialia, they cannot be included in this group; indeed, they represent a mode of termination of the great cardiac vein, which, so far as I am aware, has not been noticed in any other mammal.

Trachea and Lungs.

Trachea.—The following is the length of the trachea as it was exhibited in each marsupial examined:—

Thylacine,	6¾ inches,	34 cartilaginous rings.
Cuscus,	3 „	26 „
Dasyure,	2 „	25 „
Vulpine phalanger,	2¼ „	29 „
Phascogale,	1 „	21 „

In the *Thylacine*, *Cuscus*, *Dasyure*, and *Phascogale* the tracheal rings were deficient superiorly throughout the entire length of the tube; in the *Vulpine phalanger* they constituted complete rings round the tube in the anterior half of the windpipe; behind this they were deficient above.

Lungs.—In the *Thylacine* and *Dasyure* the left lung is undivided by any marked fissure, in the former, however, the margin is deeply crenated, whereas in the latter it is uniform. In the *Cuscus*, *Phascogale*, and *Vulpine phalanger* the left lung is partially divided into two lobes of nearly equal bulk by a fissure which extends upwards from the lower sharp margin.

In each case the right lung is furnished with a well-marked pyramidal azygos lobe which is separated from the right lung by the posterior vena cava, and rests by its base upon the upper surface of the diaphragm.

In all the animals examined the right lung is divided into three lobes. This subdivision, however, is not nearly so well marked in the *Thylacine* as in the others.

Abdominal Viscera.

Thylacine.

Stomach.—The distended stomach of the *Thylacine* has a close resemblance to that

[1] Proc. Zool. Soc., 1836.

[2] Phil. Trans., vol. cl., 1850, p. 150.

of Man. The curvatures, however, are more pronounced, and the transition from the wide cardiac portion to the narrow pyloric part more sudden. The fundus rises high above the cardiac opening. The following are the measurements of the stomach of the small female specimen: –

	Inches.
Length of the lesser curvature (measured from the opening of the œsophagus to the pylorus),	4
Length of the greater curvature (measured from the cardiac orifice over the high fundus to the pylorus),	19
Girth of the organ at the cardiac orifice,	$12\frac{1}{2}$

On turning the stomach outside in, the lining mucous membrane is observed to be highly rugose—the rugæ, however, almost entirely disappearing on distension. The mucous membrane does not present the same appearance throughout. At the fundus it is thin and smooth; towards the pylorus it becomes thicker, more pulpy, and marked by numerous irregular depressions which doubtless correspond with the alveoli of the human stomach. When distended to its utmost extent the mucous membrane still shows these alveolar depressions. A marked pyloric constriction separates the stomach from the small intestine.

Intestinal canal.—The intestinal canal proceeds backwards as a uniform tube, and at the pelvis becomes continuous with the rectum. There are no indications by which it can be divided into a small and large intestine. It is remarkably short, and diminishes slightly in calibre as it is traced towards the pelvis The rectal portion, however, expands so as to assume a diameter equal to, or even greater than that of the upper or duodenal part. The following is the length of the canal in the two specimens :—

	Feet.	Inches.
Length of the intestinal canal (Male),	6	5
do. do. (Female),	4	8
Girth when fully distended with spirit (Male)—		
(*a*) Duodenal end,	0	5
(*b*) Immediately above the rectum,	0	$4\frac{1}{4}$

Owen[1] gives the length of the intestinal canal in a *Thylacine* which measured 3 feet 4 inches from snout to vent as 9 feet 8 inches. This is relatively very much longer than in either of the Challenger specimens.

The intestinal villi are remarkable for their great length (Pl. X. figs. 1, 2, 3, and 4). In the anterior part of the tube they are fully half an inch long, and are arranged sparsely over the mucous surface, so that the interior of the gut has a rough shaggy appearance. In the anterior portion of the intestine they are filamentous and

[1] Article "Marsupialia" Cyclopædia of Anat. and Phys., p. 304.

slender, but they gradually become stouter and club-shaped (Pl. X. fig. 1). Proceeding still further back they diminish greatly in numbers, become stunted and conical, and finally arrange themselves in parallel longitudinal rows (Pl. X. figs. 2, 3, and 4). About 16 inches above the anal orifice they disappear.[1]

Plate X. fig. 5 represents a small portion of the intestine of the Lion, inverted to show the villous surface. Comparing this with fig. 1 it will be seen that the character of the villi in the *Thylacine* is altogether different. In the former the mucous surface is fleecy, and in the latter it is shaggy.[2]

Peyer's patches.—One Peyer's patch of enormous extent begins about 16 inches above the anus, and extends forwards for 22½ inches in the male, and 14 inches in the female. It is not placed opposite the mesenteric attachment but coincides with it, and it presents a minutely honey-combed appearance. In connection with this patch the mucous membrane is elevated into a feebly-marked ridge which runs along its whole length, and frequently divides and reunites. Alveolar pits are grouped upon and on either side of this ridge. Figure 3 (Pl. X.) represents the lower end of this patch.

In addition to this large patch there are several others placed further forwards in the gut (viz., three in the male and five in the female). In the male these were from one to two inches long; in the female they were with one exception (viz., that figured in Pl. X. fig. 4) not more than half an inch long. The small Peyer's patches are much obscured by villi, and can only be detected by a careful search.

In the rectum the mucous membrane is perfectly smooth, and is everywhere perforated with the minute orifices of Lieberkühnean glands. These are quite visible to the naked eye.

The intestinal canal is suspended from the upper abdominal wall by a simple mesentery.

Cuscus.

Stomach.—This stomach is smaller than that of the *Vulpine phalanger*. It is pyriform in shape with the pyloric end bent upwards upon itself, and held in position by a strong band which bridges across, and continues the lesser curvature over the constriction. When this band remains uncut the œsophagus joins the stomach at the middle of the lesser curvature; when it is divided and the pyloric end of the stomach freed, the gullet enters much nearer the left than the right extremity of the curvature.

The cardiac cul-de-sac rises high above the cardiac orifice, and the œsophagus traverses the abdomen for fully an inch before it enters the stomach.

[1] The mucous lining of the intestine of the *Dasyurus viverrinus* is provided with extremely small villi, barely visible to the naked eye. They are filamentous in form and are sparsely set. The zone of glands mentioned by Professor Owen (Proc. Zool. Soc., 1835), as being present at the commencement of the duodenum of the *Dasyurus macrurus* is apparently absent in the *Viverrine Dasyure*. It is also absent in *Thylacine*.

[2] The villi of the anterior part of the intestine in Thylacinus are very similar to those in the small intestine of the Rhinoceros. They are quite as long, but are not nearly so thickly set upon the mucous surface.

The stomach has thick muscular walls, and the duodenum is marked off by a deep constriction.

Internally, the mucous membrane is rugose when the organ is flaccid, but the folds disappear upon distention. Along the lesser curvature, and towards the pylorus, the same alveolar depressions which were noticed in the stomach of the *Thylacine* are observed in the stomach of the *Cuscus*. The following are the measurements:—

	Inches.
Length of the greater curvature from the highest point of the cardiac cul-de-sac to the pylorus, . . .	9
Length of the lesser curvature between the same points, .	$2\frac{1}{2}$

Small intestine.—The small intestine measured 5 feet 4 inches in length. The calibre of the gut gradually diminishes as we trace it towards the cæcum. The bile-duct (previously joined by the pancreatic duct) opens into the duodenum at a point $2\frac{1}{4}$ inches distant from the pyloric constriction.

The mucous membrane of the small intestine is exceedingly thin and delicate in its texture. It is covered by minute villi, which give it the usual velvety appearance.

The Peyer's patches vary greatly in size and shape. The largest was fully one inch long by half an inch broad;—the smallest was a mere speck. They were nine in number. The first was placed about twenty-two inches behind the pylorus; the last was situated five inches in front of the junction of the ileum with the cæcum.

Large intestine.—The large intestine may be divided into a cæcum, colon, and rectum.

The cæcum is very long and capacious. It measured in length 2 feet 9 inches, whilst its girth at its widest part was $5\frac{1}{2}$ inches. From the entrance of the ileum to its extremity, it tapers uniformly and terminates in a blind end which is little larger than the stem of an ordinary tobacco pipe. It shows a slight sacculation along its convexity, opposite the line of mesenteric attachment.

The colon was five feet long. It is very wide where it is continuous with the cæcum, but its calibre diminishes gradually as it is traced towards the rectum, where it assumes a diameter considerably less than that of the small intestine.

Peritoneum.—In the *Cuscus* the great omentum is very short, and composed of the usualfour layers of peritoneal membrane. The two inferior of these layers when traced forwards, are observed to enclose the stomach, form the gastro-hepatic omentum, and finally to invest the liver completely and bind it by a distinct fold to the posterior surface of the diaphragm. The two superior layers of the omentum proceed directly upwards to the spine where they separate. The anterior layer is carried forwards upon the upper abdominal wall, whilst the posterior layer leaves the spine to form an extremely voluminous mesentery ($6\frac{1}{4}$ inches long) for the colon. From the root of this fold the peritoneum again leaves the spine to form the mesentery of the small intestine which is only three inches long.

In the *Vulpine phalanger*, the mesentery of the great intestine is only four inches long, whilst that of the small intestine is five inches long.

The mesenteric glands are few in number but relatively of large size.

The cæcum has a distinct mesentery which is continued to its extremity, and is an offshoot from the meso-colon.

The duodenum is completely invested by peritoneum, and there is no demarcation of any kind between it and the jejunum.

Spleen.—In both *Thylacine* and *Cuscus* the spleen is an elongated tongue-like organ completely invested by peritoneum, and placed obliquely in the abdominal cavity. From its outer border a process of spleen substance projects towards the kidney. The splenic vessels, nerves, &c. enter the organ upon its inner surface along the line of the mesenteric attachment.

Pancreas.—The pancreas is well developed in both the *Thylacinus* and *Cuscus*. It consists of a thickened massive right extremity or head from which an elongated process of gland substance projects towards the spleen. The pancreatic duct joins the bile duct before it enters the duodenum.

Liver.—In describing the liver we shall adopt the admirable nomenclature suggested ten years ago by Professor Flower[1] in his lectures on the Comparative Anatomy of the Organs of Digestion in the Mammalia. In neither animal is there a trace of the "round ligament." This condition is to be associated with the total absence of a fossa ovalis in the heart, and of the ductus arteriosus.

In the *Cuscus* the liver is divided into a right and a left segment by a deep fissure which may be termed the umbilical cleft. It cuts the organ almost completely into two, and its significance is shown by its coinciding with the line of the suspensory ligament. The left segment, which is only very slightly smaller than the right, is subdivided by a deep cleft (the left lateral fissure of Flower), into a large "left lateral lobe" and a very small "left central lobe." The right segment also consists of a "right central lobe," and a "right lateral lobe." The latter is very small and insignificant, and the fissure (right lateral fissure) which cuts it off is very deep and almost reaches the attached border of the organ. The right central lobe is the largest of all the subdivisions of the liver. Behind it is hollowed out into a deep ditch or furrow which runs in the antero-posterior direction about its middle. This furrow contains the upper end of the gall bladder and the cystic duct, and extends upwards to the portal fissure; traced forwards it widens out and at the same time deepens, and finally it becomes a distinct V-shaped cleft in the sharp free margin of the liver which allows the fundus of the gall-bladder to be seen from the front.

The accessory lobes are both present. The Spigelian lobe is well marked, and is partially sub-divided by shallow clefts into three subsidiary portions. It has a leaf-like

[1] Medical Times and Gazette, vol. i., 1872, p. 292.

form and hangs freely down from the right segment of the liver behind the portal fissure. The caudate lobe is comparatively speaking very small. It is prismatic in form.

The vena cava passes through a complete tunnel of liver substance.

The liver of the *Thylacine* differs very materially from that of the *Cuscus*. The left segment is small in comparison with the right segment, and shows no tendency whatsoever to subdivision into lateral and central lobes. The right segment, however, is divided into two equal portions by a well-marked cleft and the right central lobe shows a deep and broad deficiency in its sharp free margin for the reception of the gall-bladder. The caudate lobe is of great length (fully four inches long), and prismatic in form, whilst the Spigelian lobe is small and attached by a broad base partly to the left segment, and partly to the right segment of the liver.

The vena cava is not covered in by liver substance.

Gall-bladder and bile-ducts.—The gall-bladder in the *Cuscus* is very large and pyriform in shape. It is firmly attached in its upper half to the under surface of the right central lobe, whilst its lower half is free and projects downwards in the cleft in the free margin of this lobe. In the *Thylacine* the gall-bladder is very small and when distended it has a globular shape; in shape and size it is not unlike a large walnut. In both animals the cystic duct emerges from the upper end of the gall-bladder, and runs upwards to the portal fissure. Here it is joined by three or four hepatic ducts which issue from the various lobes, and enter it by separate orifices. The common bile duct is thus formed and before it opens into the duodenum it is joined by the pancreatic duct.

The mucous membrane lining the gall-bladder of the *Cuscus* at first sight appears to be smooth, but on close inspection it is seen to be very finely reticulated. In the *Thylacine* it presents a very strongly marked honey-combed appearance.

Genito-urinary Organs.

I regret that, owing to an unfortunate accident which happened to the pelvic viscera of the female *Thylacine* before they were examined, I am only able to give a detailed account of the genito-urinary apparatus in the male *Thylacine* and male *Cuscus*. The recent and very excellent paper by Dr. Young of Manchester, upon the Male Organs of Generation in the Koala,[1] together with the full details given by Professor Owen in his article on the Marsupialia in the Cyclopædia of Anatomy and Physiology renders this task a comparatively easy one.

Male *Thylacine* (Pl. X. figs. 6 and 7).

Kidneys, ureters, and bladder.—The kidneys present the usual reniform outline. The sinus, however, is very small, and has a very constricted outlet. On section, the

[1] Journal of Anatomy and Physiology, vol. xiii. p. 305.

organ presents a uniform medullary substance coated by a thin layer of cortical substance. The uriniferous tubules open upon the surface of a single prominent papilla which projects into the pelvis of the kidney. The ureters where they are attached to the kidneys show only a very slight expansion.

The bladder (fig. 6, *b.*, and fig. 7, *c.*) was in a contracted state, and was remarkable for its small size; indeed it was not larger than a small walnut. In shape it is ovoid—compressed from before backwards—and its walls are exceedingly thick and muscular. It is completely invested by peritoneum, and connected by a distinct fold or mesentery to the upper aspect of the lower abdominal wall. No trace of a urachus could be detected. In front the muscular fibres are disposed in strongly-marked transverse columns which are separated from each other by intervening fissures; laterally, they have a longitudinal direction, whilst behind, they run in the form of oblique bundles with furrows between them. The neck of the bladder abuts against the broad anterior end of the prostate, and its walls are much thinner than those of the body of the viscus.

The ureters (fig. 6, *a*) pierce the inner aspect of the neck of the bladder, one on each side of the mesial plane and about a quarter of an inch apart. Immediately behind these the vasa deferentia (fig. 6, *c*) pierce the commencement of the urethra.

The mucous membrane lining the bladder in its contracted state is very rugose, more especially towards the summit. Near the neck of the organ the rugosity becomes less marked, and where the neck merges into the urethra it is perfectly smooth.

The ureters pursue a curious course through the vesical wall; at first directed backwards for a distance of about a quarter of an inch they then bend suddenly forwards and increase in calibre. Each duct opens upon a prominent papilla situated at the neck of the bladder.

Testicles and vasa deferentia.—The body of the testicle is small and spherical, not more than half an inch in diameter. The epididymis on the other hand is exceedingly large, and so long that it surrounds the body of the testicle for fully three-fourths of its circumference. The vas deferens is a slender uniform tube—$7\frac{1}{4}$ inches in length. It shows no tendency to dilatation or sacculation as it approaches the neck of the bladder, and it has no diverticulum or seminal vesicle in connection with it. It sinks into the urethral wall, close to the base of the prostate, and immediately behind the point where the ureter disappears into the vesical wall.

Prostate, (fig. 6, *m*, fig. 7, *d*). The prostate is a large pyriform body, possessing a shape very similar to that of a carrot. It commences at the neck of the bladder by a broad base, and it gradually tapers away as it is traced towards the outlet of the pelvis until it is finally lost upon the urethra. In length it measured four and a half inches, whilst its base or broadest part had a diameter of three quarters of an inch. The urethra traverses its entire length and its surface is smooth and uniform, with no external marking or furrow of any kind indicative of a lobular constitution.

Prostatic portion of the urethra (fig. 7).—For about an inch and a half from its commencement, the urethra is widely dilated and fusiform in outline. From this onwards it presents a uniform calibre. The vasa deferentia, which pierce the urethral wall very obliquely, open upon the floor of this portion of the canal by two slit-like openings (fig. 7, *b*) placed close together, and about a quarter of an inch from the neck of the bladder. Up to this point the mucous lining of the tube is perfectly smooth, but immediately beyond, it is raised into a series of delicate and faintly marked longitudinal ridges which extend along the whole length of this part of the urethra. In the intervals between these ridges the prostatic ducts open in rows. These are quite visible to the naked eye, and on subjecting the prostate to pressure a small quantity of a brownish viscid fluid is observed to ooze out through the minute orifices.

There is not the slightest trace of a veru-montanal eminence in the *Thylacine;* nor is there any indication of a sinus pocularis.

Cowper's glands (fig. 6, *h* and h^2). These are four in number, two being placed upon either side of the mesial plane, the one in front of the other. The anterior gland on each side is about the size of a pigeon's egg, and it has a reniform shape ; the posterior gland is about half the size of the other and overlaps it slightly. A long slender duct emerges from the centre of each and the four ducts thus derived all enter the urethra at the point where it sinks into the erectile tissue of the corpus spongiosum. But further, each of these glandular bodies is enveloped by a complete and thick capsule of muscular fibres which is continued for a short distance upon the duct. Small fleshy slips connect these capsules with the levator penis muscle of the same side.

Penis (fig. 6).—The body of the penis measured, from the junction of the crura to the extremity of the glans, six inches. It consists of the usual constituents, viz., two corpora cavernosa, and a corpus spongiosum. At the extremity of the organ the corpus spongiosum is split into two so as to form a forked glans penis.

Posteriorly the corpora cavernosa separate widely from each other to form the crura (fig. 6, *f.* and *f.g.*). Each crus ends in a blunt rounded point, and is enveloped in a thick layer of muscular fibres. In length it is about two inches, and is firmly fixed to the margin of the pubic arch in its middle third. The posterior end is therefore free, and surrounded as it is by a muscular capsule it appears at first sight to belong to the Cowperian glands with which it lies in series.

The bulb of the penis, as is usual in Marsupials, is split mesially into two equal portions (fig. 6, *i*). These are rounded in form and are about the size of an ordinary marble. Each half is continuous by means of a broad pedicle with the erectile tissue of the corpus spongiosum of the body of the penis and each is covered by a thick capsule of muscular fibres which apparently take origin from the aponeurosis investing the pedicle.

Muscles of the Penis.—The penis is supplied with four pairs of muscles, viz.:—

1. Retractores penis (fig. 6, *k*).
2. Levatores penis (fig. 6, *e*).
3. Bulbo-cavernosi (fig. 6, *i*).
4. Ischio-cavernosi (fig. 6, *g*).

The retractores penis are two long narrow muscular bands which arise from the under surface of the sacrum and run side by side along the upper surface of the penis to the base of the forked glans where they are inserted.

The levator penis of each side springs from the inner aspect of the tuber ischii internal to the attachment of the crus penis. Passing backwards between the two crura it is inserted upon the inferior surface of the penis at the point where the crura join.

From the levatores penis fleshy slips are given off to the muscular capsules which envelope Cowper's glands. Thus two slips join the capsule of each of the anterior glands whilst one slip proceeds to the capsule of each of the posterior glands.

The bulbo-cavernosi constitute two thick and powerful muscular envelopes for the two halves of the bulb of the corpus spongiosum. In each case the fibres arise from a strong aponeurosis upon the corresponding crus penis.

The ischio-cavernosi or erectores penis enclose the crura penis. The fleshy fibres arise from the ischial tuberosity and constitute a remarkably thick covering for the crura. In Plate X. fig. 6, the erector penis of the left side (*g.f*) is represented undisturbed; on the right side, it (*g*) has been slit open so as to expose the crus.

Cuscus (Pl. X. figs. 8, 9, 10, and 11).

Kidneys, ureter, and bladder (fig. 8).—The Kidneys (*a*) differ from the same organs in *Thylacine* only in point of size. Each measured one inch in length and about three quarters of an inch in breadth. The ureters (*c*) were six inches long. They open into the bladder about a quarter of an inch apart from each other and about the same distant from the neck of the viscus.

The bladder (*m*) when distended has a size similar to that of a small hen's egg. It is uniformly oval in form—its fundus and base presenting equal proportions. The neck of the bladder is embraced by the prostate and is pierced by the vasa deferentia immediately behind the openings of the ureters.

Testicles and vasa deferentia (fig. 8).—As in *Thylacine* each testicle consists of a small body surrounded by a very large epididymis. The body (*d*) is smooth and oval and about the size of a haricot bean. The epididymis (*e*) is crescentic in form and folded round the body of the testicle, but only structurally connected with it by its upper end or globus major; below this the epididymis is held in position by a loose fold of the visceral portion of the tunica vaginalis which stretches between it and the body.

Prostate (fig. 8, *k*).—The prostate gland presents the same shape as in *Thylacine*. In length it measures fully one inch, whilst its diameter at its broadest part or base is about a quarter of an inch. Its anterior end or base embraces the neck of the bladder whilst its narrow posterior end is gradually lost upon the urethra.

Prostatic portion of the urethra (fig. 10, *c*).—The prostatic urethra is wide at its commencement, but gradually diminishes in calibre as it is traced through the gland. Its mucous lining is smooth throughout its whole length. It shows only a very slight indication of the ridges which are so very evident in the *Thylacine*, and the orifices of prostatic ducts are barely visible to the naked eye. The vasa deferentia open by two minute apertures immediately beyond the neck of the bladder and there is no trace of a veru-montanal eminence, or of a sinus pocularis.

The sinus pocularis is absent in the great majority of marsupials. The disappearance of all structures pointing back to the embryonic condition may be considered one of the distinguishing features of the order. It is therefore a fact of the greatest interest to find "an ill-defined utriculus or sinus pocularis" in the Koala.[1]

Cowper's glands (Pl. X. fig. 8, *g*, and fig. 9, *b*).—These are two in number. They are placed in the interval between the two divergent crura—one upon either side of the membranous portion of the urethra. In size they are not larger than peas, and each is provided with a distinct muscular capsule and has a narrow duct proceeding from it. This duct after a course of about a quarter of an inch pierces the urethral wall and opens into the commencement of the spongy portion of the urethra.

In the *Vulpine phalanger* the corresponding glands are four in number as in *Thylacine*, but they are exceedingly minute.

Penis.—The length of the penis from the junction of the different parts of the root to the extremity of the forked glans was $1\frac{1}{2}$ inches. The body of the organ is composed of the usual three constituents. The glans is long and forked and measured almost half an inch in length; the root of the penis has no direct attachment to the outlet of the pelvis.

The crura penis (fig. 8, *f*, and fig. 9, *c*) are remarkably long, having a length almost equal to that of the body of the penis. They are bulbous at their extremities, and widely divergent. The bulbous free end is clothed by a thick muscular capsule—the erector penis—but this is at no point attached to the pelvic bone. The narrower posterior portion of the crus is naked.

The bulb (fig. 8, *h*, and fig. 9, *d*) is double. Each half lies upon the upper surface of the uncovered portion of the corresponding crus, and is enveloped in a thick fleshy capsule—the bulbo-cavernosus. The two portions of the bulb unite to form the corpus spongiosum into which the membranous portion of the uretha sinks.

Muscles of the penis.—These are the same as in *Thylacinus*. The retractores penis

[1] Young, Jour. Anat. and Phys., vol. xiii. p. 309.

(fig. 8, *l*) and the bulbo-cavernosi (fig. 8, *h*) are identical in every respect, whilst the ischio-cavernosi (fig. 8, *f*) differ in having no pelvic attachment.

The levatores penis (fig. 8, *i*, and fig. 9, *e*) lie upon the under surface of the organ. Each muscle springs from the corresponding crus and inclines towards the mesial plane, where it joins its fellow of the opposite side to form a narrow tendon. This is continued onwards to be inserted into the base of the glans.

Anal glands (fig. 11, *b*, b^2, b^3).—These glands may be conveniently noticed here. They are six in number. Three are situated upon either side of the common opening into which they open by long independent ducts. Each gland has a muscular capsule, and consists of a single large chamber which, in the specimen examined, was filled with a brown curdy secretion. The largest of the series was about the size of a marble, whilst the smallest was as large as a haricot bean.

In the *Vulpine phalanger* the same number of anal glands is present, but they are much smaller in size. In the *Thylacine* they are absent.

Sphincter cloacæ.—This muscle presents the same connections in both *Thylacinus* and *Cuscus*. It forms a complete sheath for the anus and the numerous glands, and parts in connection with the root of the penis. The glands, &c., are packed within it, in the midst of soft fat. Above the common opening it is present in the form of a strong narrow muscular bundle. As this is traced forwards, it is observed to expand, so that on the inferior aspect of the opening it constitutes an exceedingly thin muscular web—so thin, indeed, that the structures it encloses shine through it. In front, this thin sheet of fibres has a distinct attachment on either side to the crus of the penis; behind its fibres are inserted into the skin surrounding the mouth of the common opening. It has no attachment to bone.

Marsupium of the Female *Thylacine*.

The marsupium of the female *Thylacine* which I examined, is figured in Plate IV. (fig. 3). It was evidently a very young specimen. This was manifest not only by its small size but also by the immature condition of its bones. I am inclined to believe that it had never borne young.

The marsupium was oval in form and exceedingly shallow. Its long axis, which was directed from before backwards, measured two inches, whilst its transverse diameter was one and a half inches. In front and behind there was little or no demarcation between the pouch and the surrounding skin of the abdomen. Laterally, however, it was well mapped out by prominent overhanging folds of integument. The skin forming these folds and the floor of the marsupium, was of a very delicate texture and slightly wrinkled. With the exception of some sparse white downy hair it was quite bare. At the limits of the pouch this downy hair was suddenly replaced by the ordinary hairy coat of the animal.

On the floor of the pouch there were four small conical elevations. These were very slightly raised above the general surface, and were situated in the centre of the pouch. On the summit of each elevation there was a minute aperture barely visible to the naked eye, and on applying a magnifying glass and separating the lips of the opening with a needle an exceeding minute teat was observed within. The conical elevations, therefore, simply represented the integumental sheaths of the teats.

In the description of the mammary organs of a Kangaroo by Mr. Morgan (Trans. Linnean Soc., 1826), it is stated that the teats "after once being developed by protrusion from their original situation in the substance of the gland, never again recede to their former condition, but constitute permanent marsupial teats throughout the rest of life." This statement confirms me in my opinion that the female *Thylacine* was in a virgin condition.

Sphincter marsupii (Pl. IV. fig. 4, *s.*). Reflecting the skin from the pouch a powerful sphincter muscle is exposed. It is simply a portion of the panniculus carnosus. In front the fibres decussate, whilst behind the two bands meet, and are inserted into the fibrous tissue in front of the symphysis pubis. The inner margin of the muscle is contained in the fold of integument bounding the pouch laterally, and is round and thick. Externally, the fleshy fibres blend with those of the panniculus carnosus.

Mammary glands.—The mammary glands could not be detected as structures distinct from the superficial fascia in which they are placed. Within the area, surrounded by the sphincter marsupii, several large lymphatic glands are embedded in the superficial fascia at the back part of the pouch (fig. 4, *l.g.*).

Cremaster muscle[1] (fig. 4, *c.*). This is a strongly-marked muscular band which arises by two slips (1) from the anterior superior iliac spine, and (2) from the posterior border of the transversalis muscle. Emerging from under cover of the internal oblique, it passes downwards and inwards under cover of the aponeurosis of the external oblique. It finally appears through the external abdominal ring, and passing under cover of the sphincter marsupii, spreads out under the two nipples of its own side. It was impossible to make out its precise connection with the teats. In the mammary region a large branch of the deep epigastric artery is distributed, and a large nerve, the genito-crural (fig. 4, *g.c.n.*) enters the substance of the cremaster muscle.

[1] In the male the cremaster muscle has the same origin. It envelopes the vas deferens, and spreads out upon the tunica vaginalis.

EXPLANATION OF THE PLATES.

PLATE I.—Fore Limb of *THYLACINUS CYNOCEPHALUS.*

Fig. 1. Right manus—palmar aspect—dissection of the intrinsic muscles.
Fig. 2. Right manus—dorsal aspect.
Fig. 3. Left manus—palmar aspect—adductors reflected.

Palmar layer.
- *a.* Adductor indicis.
- *b.* Adductor annularis.
- *c.* Adductor minimi digiti.
- *a.b.* Common origin of adductores annularis et indicis.
- c^1. Insertion of adductor minimi digiti.

Intermediate layer.
- g^1. Flexor brevis pollicis.
- g^2. Flexor brevis indicis.
- g^3. Flexor brevis medii.
- g^4. Flexor brevis annularis.
- g^5. Flexor brevis minimi digiti.

Dorsal layer.
- *e.* Abductor pollicis.
- d^1. First dorsal interosseus.
- d^2. Second dorsal interosseus. } Observe the double insertions
- d^3. Third dorsal interosseus. } of these two muscles.
- d^4. Fourth dorsal interosseus.
- *d.* Abductor minimi digiti.
- f^1. and f^2. Two accessory slips, probably additional parts of the abductor minimi digiti.
- *h.* Accessory abductor annularis.

Fig. 4. Muscles of the shoulder—right fore limb of the male Thylacine.
c.m. Cleido-mastoid.
cl. Rudimentary clavicle.

Fig. 4. *tr.* Trapezius.
c.d. Clavicular deltoid.
c.h. Cephalo-humeral.
p.m. Pectoralis major.
b. Biceps.
tr^2. Outer head of triceps.
b.a. Brachialis anticus (drawn backwards by a hook).
tr^1. Long or middle head of triceps.
$t.m^1$. Teres major.
i.s. Infra-spinatus.
s.s. Supra-spinatus.
s.d. Scapular deltoid.
ac. Acromion process.
$t.m^2$. Teres minor.

Fig. 5. Left fore limb of the male Thylacine.
s.c. Subclavius.
ac. Acromion process.
s.s. Supra-spinatus.
a.t. Acromio-trachelien.
tr. Trapezius.
i.s. Infra-spinatus.
s.d. Scapular deltoid.
$t.m^1$. Teres major.
tr^1. Long or middle head of triceps.
tr^2. Outer head of triceps.
d.e. Extensor secundi internodii pollicis.
r.l. Extensor digitorum secundus.
m.u. and *c.u.* Extensor carpi ulnaris, split up into two distinct muscles.
an.l. Posterior annular ligament.
m.r. and *c.r.* Extensor ossis metacarpi pollicis, split up into two portions.
c.d. Extensor communis digitorum.
c.b. Extensor carpi radialis brevior.
c.l. Extensor carpi radialis longior.
s.l. Supinator longus.
b.a. Brachialis anticus.
b. Biceps.
c. Circumflex nerve (cutaneous branch).
p.m. Pectoralis major.
c.h. Cephalo-humeral.

Fig. 5. *tr.* Trapezius.

Fig. 6. Diagram of the brachial plexus of the Thylacine.

C.V. to C.VIII. The posterior four anterior primary divisions of the cervical spinal nerves.

D.I. The anterior primary division of the first dorsal nerve.

a. Branch which connects the fourth and fifth cervical nerves.

b. and *c.* Twigs to the skin of the neck and the outer and dorsal aspects of the shoulder.

s.c. Nerve to the subclavius.

s. Suprascapular nerve.

s.s. Subscapular nerves.

p.c. Branch to the panniculus carnosus.

c.f. Circumflex nerve.

m.c. Musculo-cutaneous, which comes off in two distinct parts.

m.s. Musculo-spiral.

m. Median nerve.

u. Ulnar nerve.

i.c. Internal cutaneous nerve.

p. Phrenic nerve.

e.r. External respiratory nerve.

p.m. Twig to pectoral muscles.

PLATE II.—Fore Limb of the *CUSCUS MACULATUS.*

Fig. 1. Dissection of the pectoral muscles and of the side of the neck.

p^1. and p^2. The two parts of the pectoralis major.

p^3. Pectoralis minor.

p^4. Pectoralis quartus.

l.d. Latissimus dorsi.

p.c. Humeral portion of the panniculus carnosus.

d. Deltoid.

tr. Trapezius.

o.h. Omo-hyoid.

c.o. Cleido-occipital.

s.m. Sterno-mastoid.

c.m. Cleido-mastoid.

Fig. 2. Right manus—dorsal view—extensor tendons removed.

Fig. 3. Right manus—palmar aspect—dissection of the intrinsic muscles.

Figs. 2&3. d^1. First dorsal interosseus.
d^2. Second dorsal interosseus.
d^3. Third dorsal interosseus.
d^4. Fourth dorsal interosseous.
t. Fibrous slips connecting the tendons of the second and fourth dorsal interossei, with the heads of the adjacent metacarpal bones.
e. Abductor hallucis.
d. Abductor minimi digiti.
g^1. Flexor brevis pollicis.
g^5. Flexor brevis minimi digiti (outer head).
h. Adductor pollicis.
a. Adductor indicis.
b. Adductor annularis.
c. Adductor minimi digiti.
a.b. Fleshy fasciculus belonging to the palmar layer and connecting the bases of the index and annularis.
u.n. Ulnar nerve, dividing into superficial and deep branches.
d.n. Twig from the deep branch of the ulnar for the supply of the contiguous sides of minimus and annularis.
m.r.n. Medio-radial nerve.
d.b. Dorsal branch of medio-radial nerve.
u. Tendon of flexor carpi ulnaris.

Fig. 4. Dissection of the side of the chest, axilla, and upper arm of the *Cuscus*—left side.
p^4. Pectoralis quartus.
r.t. and $r.t^1$. Rectus thoracis.
p^3. Pectoralis minor.
p^1. and p^2. Pectoralis major.
s.c. Subclavius.
s.n. Nerve to subclavius.
cl. Clavicle.
c.d. Clavicular deltoid.
c. Coracoid process.
c.b.b. Coraco-brachialis brevis.
c.n. Circumflex nerve.
m.c.n. and $m.c.n^1$. The two parts of the musculo-cutaneous nerve.
l.d. Insertion of the latissimus dorsi.
m.s.n. Musculo-spiral nerve.
b. Biceps.
b.a. Brachialis anticus.

Fig. 4. *m.n.* Median nerve.
c.b.l. Coraco-brachialis longus.
a.i. Anconeous internus.
h. Humerus.
s.f. Supra-condyloid foramen, with the median nerve and humeral artery passing through it.
tr^3. Inner head of the triceps.
i.c.n. Internal cutaneous nerve.
d.e.n. Nerve to dorsi-epitrochear muscle.
u.n. Ulnar nerve.
d.e. Dorsi-epitrochlear muscle.
t.m. Teres major.
p.c.n. Nerve to panniculus carnosus.
s.s. Subscapularis muscle.
b.p. Brachial plexus.
e.r.n. External respiratory nerve.
s. Scalenus medius.
l.d. Latissimus dorsi.
s.m. Serratus magnus.
o.e. External oblique muscle.

Fig. 5. Extensor aspect of the left forearm of the *Cuscus*.
c.d. Extensor communis digitorum.
r.l. Extensor digitorum secundus.
c.u. Extensor carpi ulnaris.
a.e. Anconeous externus.
e.p. Extensor secundi internodii pollicis.
$e.p^1$. and $e.p^2$. The two heads of origin of the extensor secundi internodii pollicis.
e.m. Extensor medii.
m.r. and *c.r.* Extensor ossis metacarpi pollicis.
c.b. Extensor carpi radialis brevior.
$c.b^1$.
$c.b^2$. } Its three heads of origin.
$c.b^3$.
c.l. Extensor carpi radialis longior.
s.l. Supinator longus.
m.s.n. Musculo-spiral nerve.

Fig. 6. Diagram of the brachial plexus of nerves in the *Cuscus*.
C.V. to C.VIII. The anterior primary divisions of the posterior four cervical spinal nerves.

Fig. 6. D. I. First dorsal nerve (anterior primary division).

s.c. Nerve to subclavius.
s. Suprascapular nerve.
s.s. Subscapular nerve.
c. Circumflex nerve.
m.s. Musculo-spiral.
m.c. Musculo-cutaneous nerves.
m. Median nerve.
u. Ulnar nerve.
i.c. Internal cutaneous nerve.
p.m. Nerve to pectoral muscles.
p.c. Nerve to panniculus carnosus.
p. Phrenic nerve.
e.r. External respiratory nerve.

PLATE III.—Hind Limb of the *CUSCUS*.

Fig. 1. Dissection of the gluteal region and the outer aspect of the thigh.

ec.g^1. } The two parts of the ecto-gluteus.
ec.g^2. }
ec.g.^{3} The agitator caudae.
ec.g^{1*}. Insertion of the anterior part of the ecto-gluteus.
ec.g^{2*}. Insertion of the posterior part of the ecto-gluteus.
ec.g^{3*}. Insertion of the agitator caudae.
p. Pyriformis.
p.n. Pudic nerve.
s.s.n. Small sciatic nerve (this nerve should be represented as passing under cover of *c.t.*).
g.n. Nerve supplying the gemelli, the quadratus femoris, and the adductor magnus.
h.n. Nerve to the hamstring muscles.
g. Gemelli muscles.
i.f. Ischio-femoral muscle.
c.t. Caudal portion of biceps.
o.e. Obturator externus.
Q.f. Quadratus femoris.
b. Biceps.
s.t. Semi-tendinosus.
a.m. Adductor magnus.

Fig. 1. *r.f.* Rectus femoris.
g'.s.n. Great sciatic nerve.
v.e. Vastus externus.
s. Sartorius.
m.g. Meso-gluteus.
*m.g.** Insertion of meso-gluteus.
i. Iliacus.
en.g. Endo-gluteus.
s.g.n. Superior gluteal nerve.
c.i. Iliac crest.
Fig. 2. Inner aspect of the left leg of the *Cuscus*.
i.l.l. Internal lateral ligament of the knee-joint.
s.m. Semi-membranosus.
g. Gracilis.
s.t. Semi-tendinosus.
c.t. Caudal part of the biceps.
s. Slip from this to the semi-tendinosus.
t. Tibia.
Fig. 3. Ring digit of the foot of the *Cuscus*.
l. Lumbrical muscle.
f.p. Flexor profundus tendon.
f.s. Flexor sublimis tendon.

PLATE IV.—Hind Limb and Marsupium of *THYLACINUS*.

Fig. 1. Internal aspect of the thigh.
i.c.n. Internal cutaneous nerve.
a.m. Adductor magnus.
a.b. Adductor brevis.
v.i. Vastus internus.
r.f. Rectus femoris.
f.a. Femoral artery.
s. Sartorius.
a.c.n. Anterior crural nerve.
t.a. Transversalis abdominis.
o.e. Obliquus externus.
o.i. Obliquus internus.
c. Cremaster.
g.c.n. Genito-crural nerve.

Fig. 1. *m.b.* Cartilaginous nodule representing the marsupial bone.
ps. Psoas.
i. Iliacus.
o.n. Obturator nerve.
g. Gracilis.
a.l. Pectineus.
s.m. Semi-membranosus.
b^2. Superficial caudal part of the biceps.
s.t. Semi-tendinosus.
b^1. Bicipiti accessorius (Haughton).
b. Biceps.
b^3. Tibial portion of the superficial caudal part of the biceps.

Fig. 2. Dissection to show the gluteus quartus muscle in the Thylacine.
g.q. Gluteus quartus.
i. Iliacus.
v.i. Vastus internus.
v.e. Vastus externus.
rf^1. Superficial head of rectus femoris.
s. Sartorius.
l. Dorsum ilii.
rf^2. Reflected head of rectus femoris.

Fig. 3. Marsupial pouch of the female Thylacine.

Fig. 4. Dissection of the marsupial pouch of *Thylacinus*—teats left in position.
g.c.n. Genito-crural nerve.
c. Cremaster muscle.
s. Sphincter marsupii.
l.g. Lymphatic glands.

Fig. 5. Gluteal region and outer aspect of the thigh of *Thylacinus*.
h.n. Nerve to the hamstrings.
b^2. Superficial caudal part of the biceps.
s.s.n. Small sciatic nerve.
$ec.g^2$. Two portions of agitator caudae.
$ec.g^{2*}$. Insertion of agitator caudae.
b^1. Bicipiti accessorius (Haughton).
p.n. Pudic nerve.
g.n. Superior gluteal nerve.
$ec.g^1$. Ecto-gluteus.
$ec.g^{1*}$. Insertion of ecto-gluteus.
s.n. Branch from superior division of a sacral nerve.

Fig. 5. *m.g.* Meso-gluteus.
*m.g.** Insertion of the superficial part of the meso-gluteus.
en.g. Endo-gluteus.
i.f. Ischio-femoral muscle.
s. Sartorius.
r.f. Rectus femoris.
v.e. Vastus externus.
a.m. Adductor magnus.
b. Biceps.
s.t. Semi-tendinosus.
g^{t}*.s.n.* Great sciatic nerve.

PLATE V.—Hind Limb of the *CUSCUS*, with a Diagram of the Sacral and Lumbar Plexuses of the *THYLACINE*.

Fig. 1. Right pes of the *Cuscus*.
Fig. 2. Dissection of the back of the leg of the *Cuscus*.
a. Soleo-gastrocnemius.
d. Large flexor muscle.
c. Plantaris.
b^{1}. Tendon of the inner head of the gastrocnemius.
a^{1}. Tendon of soleo-gastrocnemius.
e. Superficial flexor (flexor brevis digitorum).
k. Annular ligament.
t. Tibia.
g. Tibialis posticus externus.
f. and *f*^{1}. Tibialis posticus internus.
h. Semi-membranosus.
l. Internal lateral ligament of the knee-joint.
b. Inner head of gastrocnemius.
i. Femur.
1. External saphenous nerve.
2. Communicating branch from this to external plantar.
3. External plantar nerve.
4. Internal popliteal nerve.
5. Muscular branch from internal popliteal.
6. Internal plantar nerve.
7. Nerve to the hallux.
8. Twig from internal plantar to the superficial flexor.

Fig. 3. Anterior and outer aspects of the right leg of the *Cuscus*.

a^1. and a^2. The two heads of the peroneus longus.

c. Fibular head of extensor brevis digitorum for the minimus.

c^t. Its tendon.

d. Fibular head of extensor brevis digitorum for the ring digit.

d^t. Its tendon.

l^1. to l^4. Annular ligaments.

b. Peroneus brevis.

b^t. Its tendon.

e. Extensor longus digitorum.

f. Tibialis anticus.

a^t. Tendon of peroneus longus.

k^1. Abductor ossis metatarsi minimi digiti.

k^3. Abductor minimi digiti (inserted into the extensor tendon).

k^2. Abductor minimi digiti (inserted into sesamoid).

h. Pedal portion of extensor brevis digitorum.

g^t. Tendon of extensor longus hallucis.

1. External popliteal nerve.
2. Anterior tibial nerve.
3. Musculo-cutaneous nerve.

Fig. 4. Posterior view of the right thigh of the *Cuscus* to show the adductor muscles.

t. Root of the tail.

a. Ischial tuberosity.

h. Obturator internus.

c. Quadratus femoris.

g^t. Obturator externus.

b. Femur.

d. Adductor magnus.

e^1. Femoral opening in adductor brevis.

e. Adductor brevis.

f. Gracilis.

1. Obturator nerve.

Fig. 5. Diagram of the lumbar and sacral plexuses in the Thylacine.

Fig. 6. Diagram of the lumbo-sacral plexus in *Cuscus*.

I. L. to VI. L. The six anterior primary divisions of the lumbar nerves.

I. S. and II. S. Anterior primary divisions of the first and second sacral nerves.

g.c. Genitocrural nerve.

e.c. External cutaneous nerve.

Fig. 6. *s.* Twig to sartorius muscle.
a.c. Anterior crural nerve.
o. Obturator nerve.
s.g. Superior gluteal nerve.
g.m. Branch to gluteus maximus.
h. Nerve to hamstrings.
g.s. Great sciatic nerve.
s.s. Small sciatic nerve.
p. Pudic nerve. (The twig marked "*p*" in fig. 6, which springs from the third lumbar nerve, goes to the psoas muscle.)

PLATE VI.—Dissections of the Feet of *THYLACINUS* and *CUSCUS*.

Fig. 1. Dissection of the intrinsic muscles of the left foot of the Thylacine. A probe has been introduced between the plantar layer of adductores and the intermediate layer of flexores breves.

p^2. Adductor indicis.
p^4. Adductor annularis.
p^5. Adductor minimi digiti.
} Plantar layer.

$f^2.o$. Outer head of flexor brevis indicis.
$f^2.i$. Inner head of flexor brevis indicis.
$f^5.o$. Outer head of flexor brevis minimi digiti.
$f^5.i$. Inner head of flexor brevis minimi digiti.
d^2. First dorsal interosseus.
d^6. Abductor ossis metatarsi minimi digiti.
$d^{6'}$. and $d^{6''}$. The two abductors of the minimus.
1. External plantar nerve.
2. Deep division of external plantar nerve.
3 and 4. The two digital branches of the superficial division of the external plantar nerve.

Fig. 2. The same foot of the Thylacine. The plantar adductores have been thrown down, and a probe introduced between the intermediate flexores breves and the dorsal abductors.

The corresponding letters in fig. 1 indicate corresponding structures in this figure.

f^2. Flexor brevis indicis.
f^3. Flexor brevis medii.
f^4. Flexor brevis annularis.
f^5. Flexor brevis minimi digiti.
} Intermediate layer.

Fig. 2. d^{2}. and $d^{2'}$. The two parts of the abductor indicis or first dorsal interosseus.
d^{3}. Second dorsal interosseus.
d^{4}. Third dorsal interosseus.
d^{5}. Fourth dorsal interosseus. } Dorsal layer.
d^{6}. Abductor ossis metatarsi minimi digiti.
$d^{6'}$. Abductor minimi digiti (the part inserted into the extensor tendon).
$d^{6''}$. Abductor minimi digiti (the part inserted into the sesamoid bone). } Dorsal layer.

Fig. 3. Diagram of the distribution of the cutaneous nerves on the dorsum of the left foot of *Thylacinus*.
1. Anterior tibial nerve.
2. Musculo-cutaneous nerve.
3. External saphenous nerve.

Fig. 4. Diagram of the cutaneous distribution of the plantar nerves in the left foot of the Thylacine.
1. External plantar nerve.
2. Internal plantar nerve.
3. Superficial division of the external plantar nerve.
4. Deep division of the external plantar nerve.

Fig. 5. Dissection of the intrinsic muscles of the right foot of the *Cuscus*. The plantar cartilage (*p.c.*) has been divided and the outer portion thrown outwards along with the opponens minimi digiti (op^{5}.).
p^{1}. Adductor hallucis.
r. Raphe.
p^{4}. Adductor annularis.
p^{5}. Adductor minimi digiti.
f^{1}. Flexor brevis hallucis.
f^{5}. Flexor brevis minimi digiti.
op^{5}. Opponens minimi digiti.
d^{1}. Abductor hallucis.
d^{6}, $d^{6'}$, $d^{6''}$. The three adductors of the minimus.
p.c. Plantar cartilage.
p.t. Plantaris tendon.
1. Nerve to hallux.
2. External plantar nerve.
3. Superficial division of the external plantar.
4. Deep division of external plantar.

Fig. 6. Right foot of the *Cuscus*. The adductores have been removed and the flexores breves thrown down so as to expose the dorsal abducting muscles.

p^1. Adductor hallucis.

f^2. to f^5. Flexores breves.

d^2. to d^5. Dorsal interossei.

d^4. Approximator of medius and annularis.

d^5. Approximator of the annularis and minimus.

$d^{4'}$. Abducting slip of the third dorsal interosseus.

$d^{5'}$. Abducting slip of the fourth dorsal interosseus.

d^3. Represents the deep part of the inner head of the flexor brevis medii artificially separated. It is supposed to represent the second dorsal interosseus.

ops. Opponens minimi digiti.

p.t. Peroneus longus tendon.

Fig. 7. Diagram of the cutaneous distribution of the plantar nerves in the right foot of the *Cuscus*.

1. Nerve to hallux.
2. Internal plantar nerve.
3. External plantar nerve.
4. Superficial division of external plantar nerve.
5. Deep division of external plantar nerve.
6. Communication between internal plantar nerve and the nerve to the hallux.

Fig. 8. Diagram of the cutaneous nerves on the dorsum of the right foot of the *Cuscus*.

1. External saphenous.
2. Musculo-cutaneous.
3. Long saphenous.
4. Dorsal twig from the nerve to the hallux.

PLATE VII.—The Feet of the *KOALA* and *VIRGINIAN OPOSSUM*.

Fig. 1. The right pes of the Koala.

Figs. 2 and 3. The same foot dissected so as to show the superficial and deep intrinsic muscles.

o.c. Os calcis.

l. Levator muscle of the heel.

c. Plantar cartilage forming the true heel.

p^1. Adductor hallucis.

p^2. and p^3. Adductor of the medius and index.

Figs. 2 and 3. p^5. Adductor of the minimus.
f^1. Flexor brevis hallucis.
f^2. Flexor brevis indicis.
f^3. Flexor brevis medii.
f^4. Flexor brevis annularis.
$f^5.t$. Tibial head of flexor brevis minimi digiti.
o.m. Opponens minimi digiti.
d^1. Abductor hallucis.
d^2. First dorsal interosseus.
d^6. Two parts of abductor minimi digiti.
a.m. Abductor ossis metatarsi minimi digiti.

Figs. 4 and 5. Superficial and deep dissections of the intrinsic muscles of the left foot of the Virginian Opossum.
p^1. Adductor hallucis.
p^2. Adductor indicis.
p^4. Adductor annularis.
p^5. Adductor minimi digiti.
f^1. to f^5. Flexores breves.
d^1. Abductor hallucis.
d^2. First dorsal interosseus.
$d^5.f$. and $d^5.t$. Two parts of the abductor minimi digiti.
a.m. Abductor ossis metatarsi minimi digiti.

PLATE VIII.—Intrinsic Muscles in the Feet of various Mammals.

Fig. 1. Left foot of the *Bathyergus capensis*.
f^1. to f^5. Flexores breves.

Fig. 2. Left foot of the otter.
p^1. Adductor hallucis.
p^2. Adductor indicis.
p^5. Adductor minimi digiti.
o.m. Opponens minimi digiti.
f^1. to f^5. Flexores breves.
$f^5.f$. Fibular head of flexor brevis minimi digiti.
$f^5.t$. Tibial head of flexor brevis minimi digiti.
d^2. to d^5. Dorsal interossei.
a.o. Abductor ossis metatarsi minimi digiti.

Fig. 3. Left foot of the Armadillo.

Fig. 3. p^1. Adductor hallucis.
p^2. Adductor indicis.
p^4. Adductor annularis.
p^5. Adductor minimi digiti.
$f^1.t$. Tibial head of flexor brevis hallucis.
$f^1.f$. Fibular head of flexor brevis minimi digiti.
f^5. Flexor brevis minimi digiti.
d^1. Abductor hallucis.
d^6. Abductor minimi digiti.
a.o. Abductor ossis metatarsi minimi digiti.
f.b. Fibrous bands.

Fig. 4. Dorsal aspect of the left pes of a dog to show the close apposition of the metatarsal bones.

Figs. 5 and 6. Dissections of the left pes of the Tamandua.
p^1. Adductor hallucis.
p^2. Adductor indicis.
p. Transversus indicis.
p^5. Adductor annularis.
f^1. to f^5. Flexores breves.
$f^5.t$. Tibial head of flexor brevis minimi digiti.
$f^5.f$. Fibular head of flexor brevis minimi digiti.
d^1. Abductor hallucis.
d^2. to d^5. Dorsal interossei.
d^6. Abductor minimi digiti.
a.o. Abductor ossis metatarsi minimi digiti.
e.p.n. External plantar nerve.

Fig. 7. Dorsal aspect of the left foot of the Leopard.
d^3. Second dorsal interosseus.
d^4. Third dorsal interosseus.
d^5. Fourth dorsal interosseus.

Fig. 8. The plantar aspect of the same foot.
p^2. Adductor indicis.
p^5. Adductor annularis.
o.m. Opponens minimi digiti.
d^2. to d^5. Dorsal interossei.
d^6. Abductor minimi digiti.
a.o. Adductor ossis metatarsi minimi digiti.
f^2. to f^5. Flexores breves.

PLATE IX.—The Thoracic Viscera of *THYLACINUS*, and the Feet of various Mammals.

Fig. 1. The heart and lungs of *Thylacinus*.

a. Subclavian vein (right).
b. Internal jugular vein (right).
c. Right subclavian artery.
d. Right common carotid artery.
e. Left common carotid artery.
f. Left subclavian artery.
g. Left internal jugular vein.
h. Left subclavian vein.
i. Superior intercostal vein.
n. Left anterior vena cava.
k. Posterior vena cava.
m. Right anterior vena cava.
l. Azygos vein.

Fig. 2. Dorsal aspect of the left foot of the Three-toed Sloth.

fl.br.d. Extensor brevis digitorum.
d^2. First dorsal interosseus.
d^3. Second dorsal interosseus.
d^4. Third dorsal interosseus.
d^5. Fourth dorsal interosseus.

Fig. 3. Palmar aspect of the left manus of the Three-toed Sloth.

2^{nd} *p.i*. Second phalanx of the index.
2^{nd} *p.m*. Second phalanx of the medius.
2^{nd} *p.a*. Second phalanx of the annularis.
p^{2*}. Adductor indicis.
p^2. Transversus indicis.
p^4. Adductor annularis.
f^1. Flexor brevis pollicis.
$f^2.r$. Radial head of flexor brevis indicis.
f^4. Flexor brevis annularis.
f^5. Flexor brevis minimi digiti.
d.u.n. Deep division of the ulnar nerve.

Fig. 4. The same manus with the adductors reflected (drawn somewhat larger than nature).

$p.^2$ Transversus indicis.

Fig. 4. p^{2*}. Origin of adductor indicis.
$p^{4'}$. Insertion of adductor annularis.
p^{4*}. Origin of adductor annularis.
$f^2.r$. Radial head of flexor brevis indicis.
$f^2.u$. Ulnar head of flexor brevis indicis.
f^4. Flexor brevis annularis.
f^5. Flexor brevis minimi digiti (dragged inwards).
d^2. to d^5. Dorsal interossei.
$p^{2'}$. Insertion of adductor indicis.
h. Rudimentary hallux.
a. Rudimentary minimus.

Fig. 5. Diagram of the dorsal interossei of the left foot of the *Ornithorhynchus paradoxus*.
d^2. to d^5. Dorsal interossei.

Fig. 6. Plantar aspect of the left foot of the *Echidna setosa*.
p^1. Adductor hallucis.
p^2. Adductor indicis.
p^3. Adductor medii.
p^4. Adductor annularis.
$p^{4'}$. Additional slip of the adductor annularis.
p^5. Adductor minimi digiti.
f^1. Flexor brevis hallucis.
f^2. Flexor brevis indicis.
f^5. Flexor brevis minimi digiti.
$f.d$. Outermost belly of the flexor brevis digitorum.
d^1. Abductor hallucis.
d^3. Second dorsal interosseus.
e.p.n. External plantar nerve.

Fig. 7. Left foot of the horse—plantar aspect.
f^3. The suspensory ligament of the fetlock (flexor brevis medii).
d^3. Second dorsal interosseus.
d^4. Third dorsal interosseus.

PLATE X.—Abdominal and Pelvic Viscera of *THYLACINUS* and *CUSCUS*.

Fig. 1. A small portion of the upper part of the intestinal canal of the Thylacine to shew the long club-shaped villi.

Fig. 2. A small portion of the lower part of the intestinal canal of the Thylacine to show the short erect villi arranged in longitudinal rows.

Fig. 3. A portion of the lower part of the intestinal canal of the Thylacine turned inside out, and distended with spirit to show the large Peyer's patch (*p.*).

Fig. 4. A portion of the lower part of the intestinal canal of the Thylacine to show a small Peyer's patch (*p.*).

Fig. 5. Small intestine of a lion turned inside out to show the fleecy villi.

Fig. 6. Genito-urinary organs of the male Thylacine displayed by the removal of the sacrum.

a. Ureter.
b. Bladder.
c. Vas deferens.
d. Membranous portion of urethra.
e. Levator penis.
f. Crus penis.
g. Erector penis.
f.g. Crus penis, clothed by the erector penis.
h. and h^2. Cowper's glands enveloped in their muscular capsules.
i. Bulb of the penis enveloped by the bulbo-cavernosus muscle.
k. Retractor penis.
l. Penis.
m. Prostate.

Fig. 7. Bladder and prostatic urethra of the male Thylacine laid open (slightly enlarged).

c. Bladder.
a. Bristle in the ureter.
b. Bristle in the vas deferens.
d. Prostate.

Fig. 8. Genito-urinary organs of the male *Cuscus*.

a Kidney
c. Ureter.
d. Body of testicle.
e. Epididymis.
f. Crus penis clothed by erector penis.
g. Cowper's gland.
h. Bulb of penis clothed by bulbo-cavernosus.
i. Levator penis.
k. Prostate.
l. Retractor penis.
m. Bladder.

Fig. 9. Under surface of the penis of the *Cuscus* to show the levator penis.

a. Membranous urethra.

b. Cowper's gland.

c. Crus penis clothed by the erector penis.

d. Bulb of penis.

e. Levator penis.

Fig. 10. Bladder and prostatic urethra of the male *Cuscus* laid open.

a. Bladder.

b. Bristles in the ureters.

c. A bristle in the right vas differens (the opening of the left vas could not be found).

d. Prostate.

e. Crus penis.

Fig. 11. Anal glands of the *Cuscus*.

a. Rectum.

b, b^2, and b^3. Anal glands.

c. Penis.

PLATE XI.—Feet of the *FOX-BAT*, *WALRUS*, *ELEPHANT*, *DASYURE*, and *HARE*; also certain Figures illustrative of the Structure of the Suspensory Ligament in the Horse, Ox, and Sheep.

Fig. 1. Plantar aspect of the left foot of the fox-bat; adductors thrown down.

Fig. 2. Plantar aspect of the right foot of the same animal.

p^1. Adductor hallucis.

p^5. Adductor minimi digiti.

f^1. to f^5. Flexores breves.

$d^{6'}$. Abductor ossis metatarsi minimi digiti.

e.p.n. External plantar nerve.

d.d. Deep division.

s.d. Superficial division.

i.p.n. Internal plantar nerve.

Fig 3. Plantar aspect of the left foot of a young walrus.

$p^1.o.$ Adductor obliquus hallucis.

$p^1.t.$ Adductor transversus hallucis.

p^5. Fibrous cord in the place of adductor minimi digiti.

f^1. to f^5. Flexores breves.

$f^1.t.$ Tibial head of flexor brevis hallucis (?).

Fig. 3. f^1f. Fibular head of flexor brevis hallucis.
d^1. Abductor hallucis.
d^4. Third dorsal interosseus.
$d^{6'}$. Abductor ossis metatarsi minimi digiti.
d^6. Abductor minimi digiti.
d^{6*}. Accessory part of abductor minimi digiti.
e.p.n. External plantar nerve.
d. Deep division.
s. Superficial division.
i.p.n. Internal plantar nerve.

Fig. 4. Plantar aspect of the right foot of a fœtal elephant.
$p^2.t$. Transversus indicis.
p^2. Fibrous cord representing adductor indicis.
f^2. to f^5. Flexores breves.
$f^5.t$. Tibial head of flexor brevis minimi digiti.
d^6. Abductor minimi digiti.
e.p.n. External plantar nerve.
i.p.n. Internal plantar nerve.

Fig. 5. Plantar aspect of the left foot of *Dasyurus viverrinus*.

Fig. 6. Plantar aspect of the right foot of the same animal ; adductores removed.
p^1. Adductor hullucis.
p^2. Adductor indicis.
p^4. Adductor annularis.
p^5. Adductor minimi digiti.
r. Raphe.
f^1. to f^5. Flexores breves.
$f^1.t$. Tibial head of flexor brevis hallucis.
$f^4.f$. Fibular head of flexor brevis annularis.
d^2. to d^5. Dorsal interossei.
d^6, d^{6*}, and $d^{6'}$. The three separate parts of the abducting apparatus of the minimus.
e.p.n. External plantar nerve.
s. Superficial division.
d. Deep division.

Fig. 7*a*. Transverse section through the suspensory ligament of the fetlock of the horse (*a*) Indicates the point in this section which is enlarged in fig. 7.

Fig. 7. The point "*a*" in fig. 7*a* as seen under a magnifying power of fifty diameters.
n. Nerve.
f. Adipose tissue.

Fig. 7. *m.* Muscular tissue.
t. Tendinous tissue.
v. Blood-vessels.
Fig. 8*a*. Transverse section through the suspensory ligament of the ox.
(*a*) Indicates the point in this section which is enlarged in fig. 8.
Fig. 8. The point "*a*" in fig. 8*a* as seen under a magnifying power of fifty diameters.
n. Nerves.
f. Adipose tissue.
m. Muscular tissue.
v. Blood-vessels.
t. Tendinous tissue.
Fig. 9*a*. Transverse section through the suspensory ligament of the sheep.
(*a*) Indicates the part which is enlarged in fig. 9.
Fig. 9. The point "*a*" in fig. 9*a* as seen under a magnifying power of fifty diameters.
t. Tendinous tissue.
f. Adipose tissue.
n. Nerve.
v. Blood-vessel.

PLATE XII.—Sternum and Vertebræ of the *THYLACINE.*

Fig. 1. Sternum of the female Thylacine, with portions of the ribs and the costal cartilages attached.
(*a*) First rib entire.
Fig. 2. Axis vertebra—left side. (*a*) Points to the layer of epiphysial cartilage which intervenes between the superior articular processes and the odontoid process on the one hand, and the body of the vertebra on the other.
Fig. 3. Cervical vertebra—from the middle of the series—right side.
Fig. 4. Dorsal vertebra—from the middle of the series—right side.
Fig. 5. Fourth lumbar vertebra—left side.
Fig. 6. Sacrum—dorsal view.

PLATE XIII.—Bones of the Fore and Hind Limbs of the *THYLACINE.*

Fig. 1. Right humerus—arrow directed through the supra-condyloid foramen
Fig. 2. Right radius.
Fig. 3. Right ulna.

Fig. 4. Right femur.
Fig. 5. Right fibula.
Fig. 6. Right tibia.
Fig. 7. The innominate bones of the female Thylacine—inferior aspect.
(*a*) The cartilaginous nodules, which represent the marsupial bones. They are apparently a direct continuation upwards of the cartilage which intervenes between the ossa innominata at the symphisis pubis.
(*b*) Ligament connecting the marsupial cartilage with the pectineal eminence.

In concluding this Report the author feels under heavy obligations to the gentlemen who have so faithfully delineated the various objects in the accompanying plates. More especially is he indebted in this respect to J. Dunlop Dunlop, M.B. (now in Adelaide, Australia), who has contributed eight plates, and to Arthur Thomson, M.B., Senior Demonstrator of Anatomy in the University of Edinburgh, who has executed two plates, and at the same time superintended the drawing of the Plates XII. and XIII. by Mr. T. Lauder Sawers. As already stated, the plate representing the feet of the Koala and the Virginian Opossum is the work of Alfred H. Young, F.R.C.S., of Manchester, and was drawn from his own dissections.

Fig. 3

Fig. 2

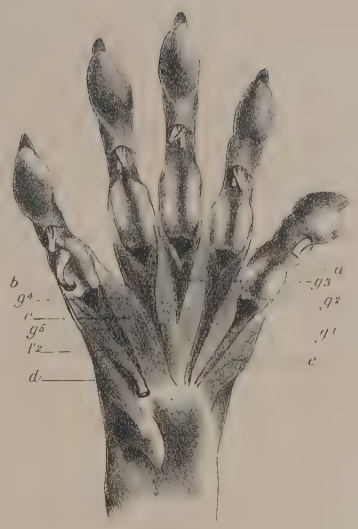


Fig. 1

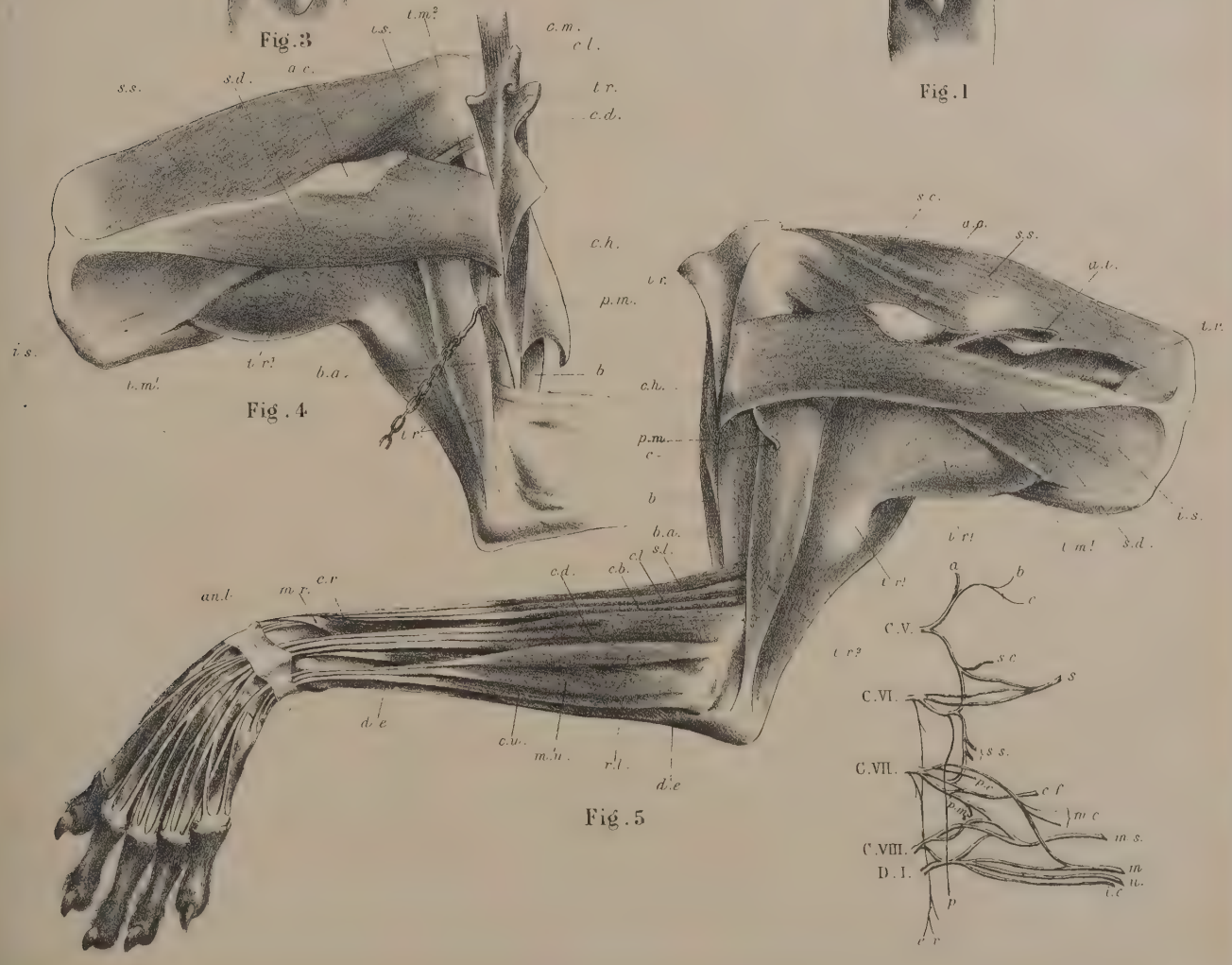


Fig. 5

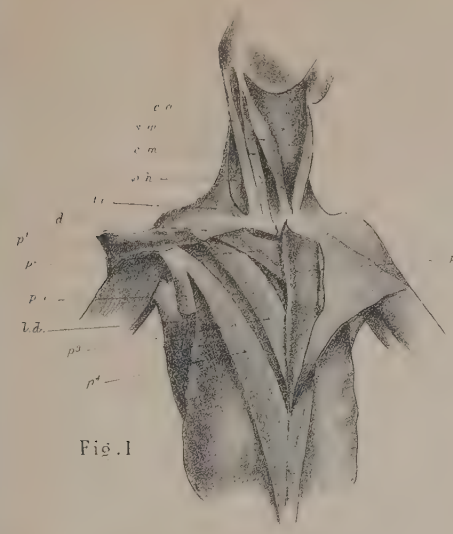


Fig. 1

Fig. 2

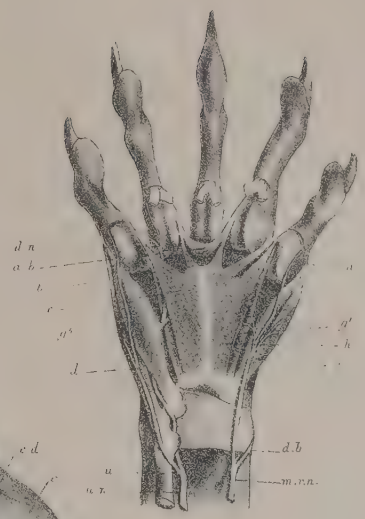


Fig. 3

Fig. 4

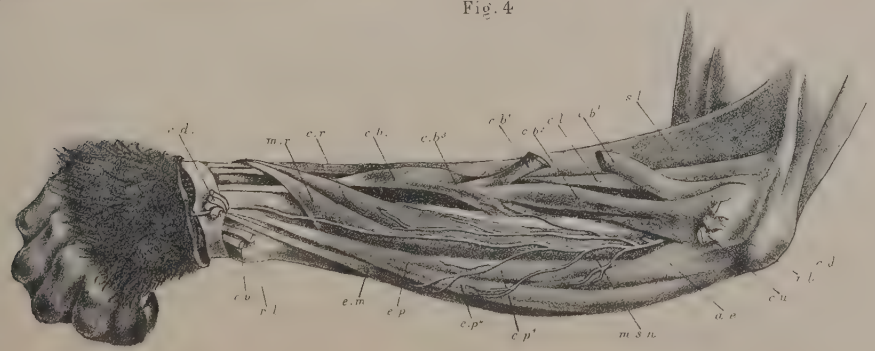


Fig. 5

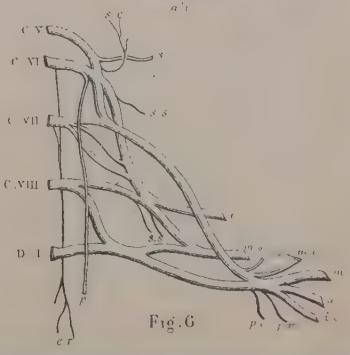


Fig. 6

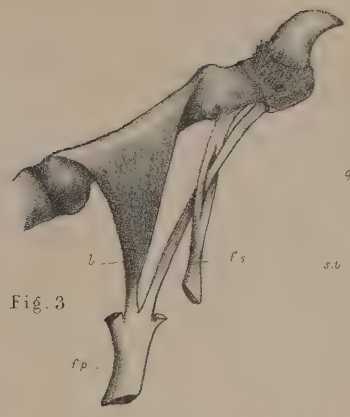


Fig. 3

Fig. 2

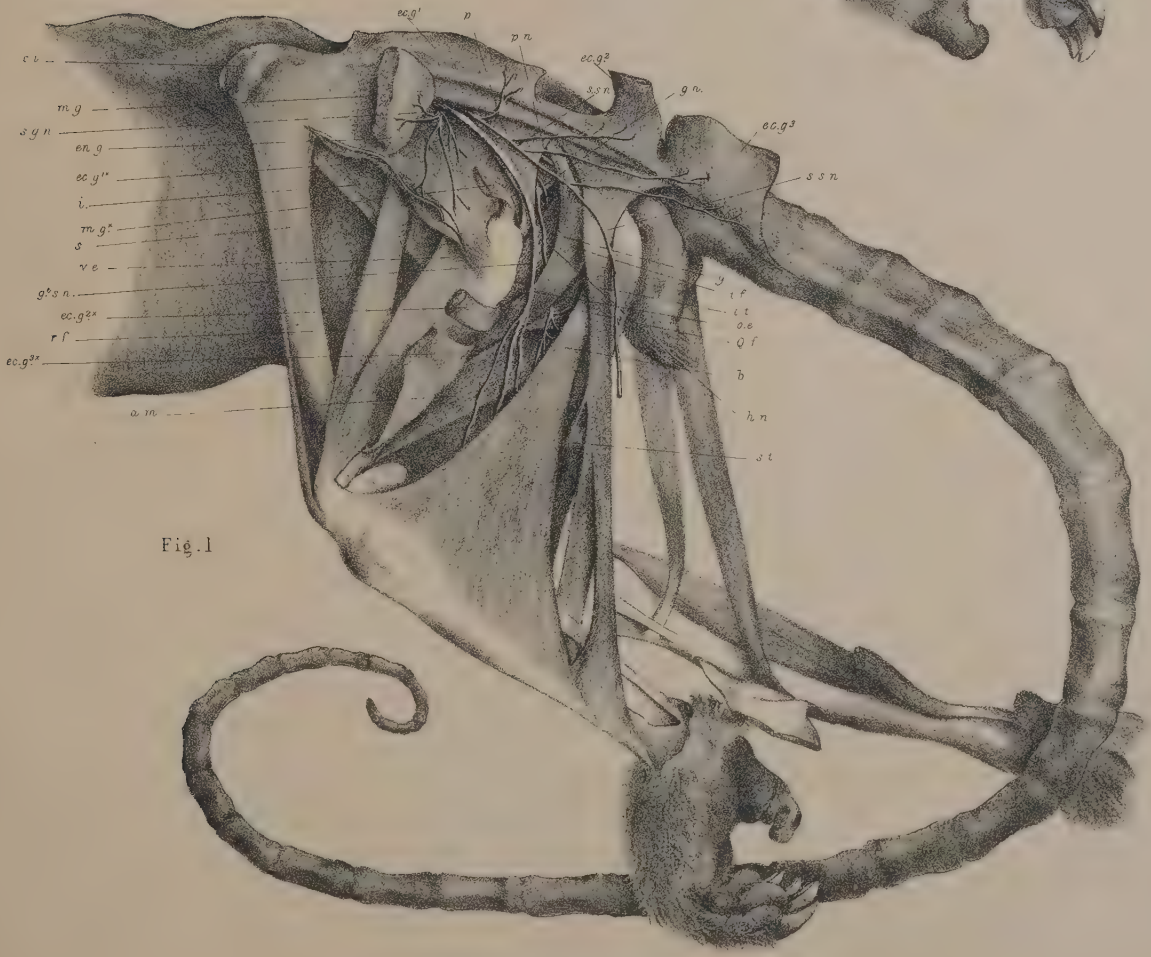


Fig. 1

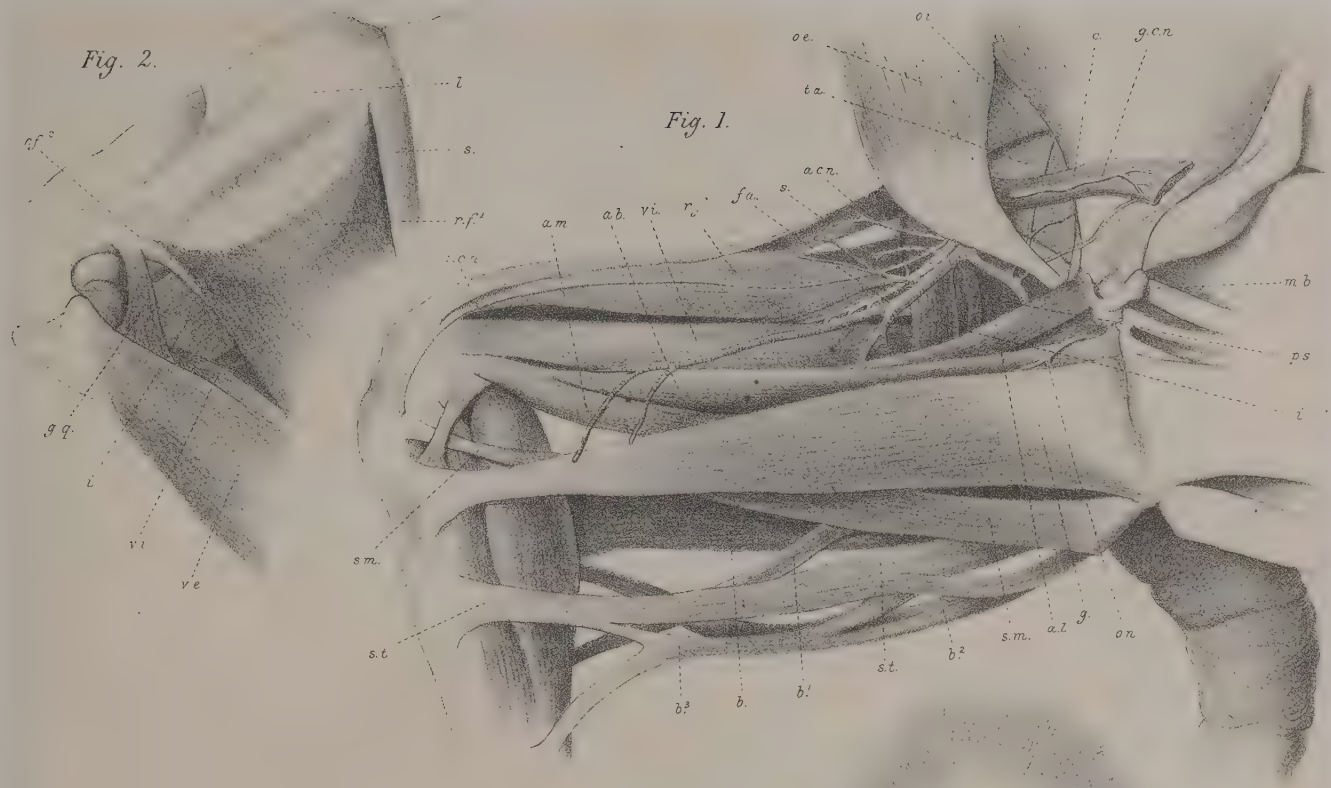


Fig. 2.
l
s.
r.f.¹
r.f.²
g.q.
i.
v.i
v.e
Fig. 1.
o.e.
o.i.
c.
g.c.n.
t.a.
a.c.n.
s.
f.a.
a.m
a.b.
v.i.
r.
m.b
p.s
i
s.m.
s.t
b.³
b.
b.'
s.t.
b.²
s.m.
a.l.
g.
o.n

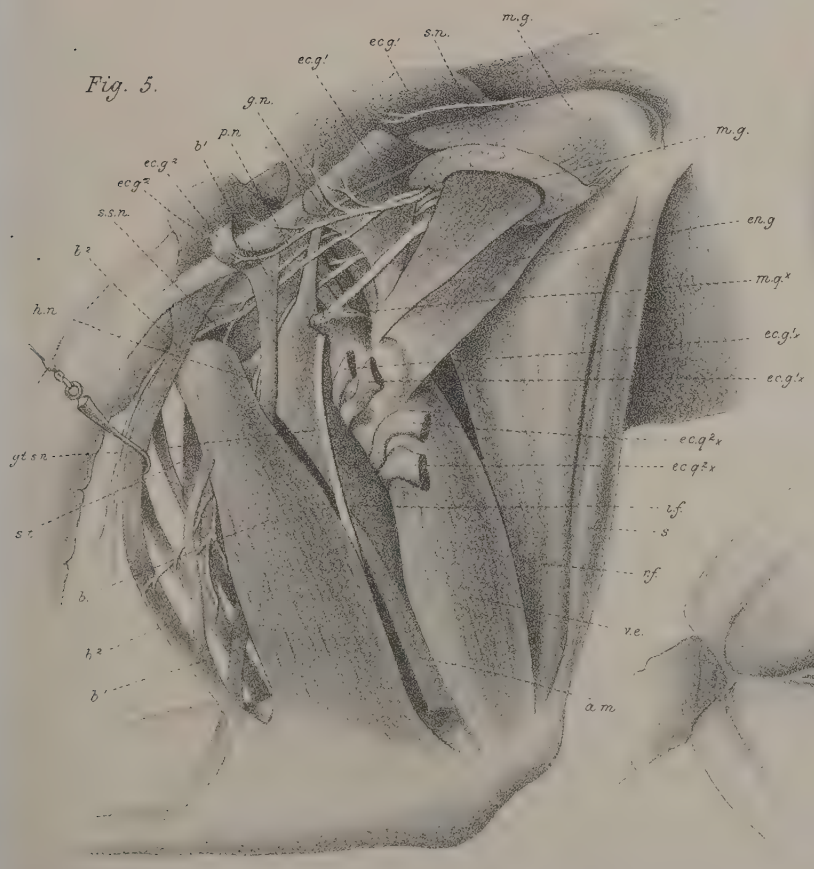


Fig. 5.
m.g.
s.n.
ec.g.'
ec.g.'
g.n.
p.n.
b'
ec.g.²
ec.g.²
s.s.n.
l.²
h.n.
g.t.s.n.
s.t.
b.
h.²
b'
m.g.
en.g
m.q.ˣ
ec.g.'ₓ
ec.g.'ₓ
ec.q.²ₓ
ec.q.²ₓ
i.f.
s
r.f.
v.e.
a.m.

Fig. 3.

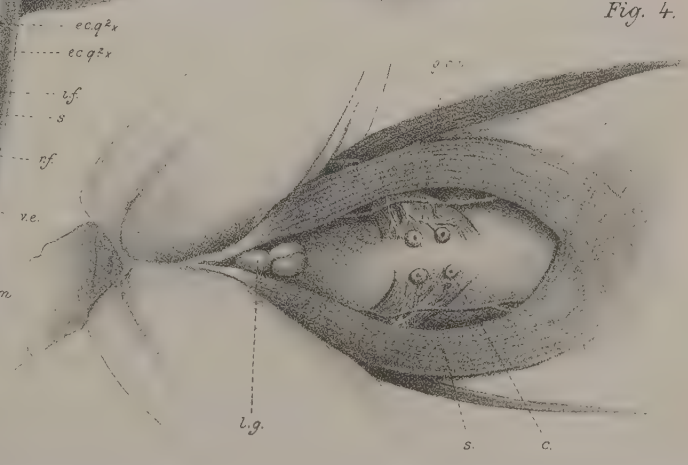


Fig. 4.
g.c.n.
l.g.
s.
c.

Fig. 2.

Fig. 1.

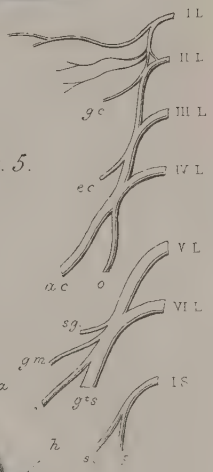


Fig. 5.

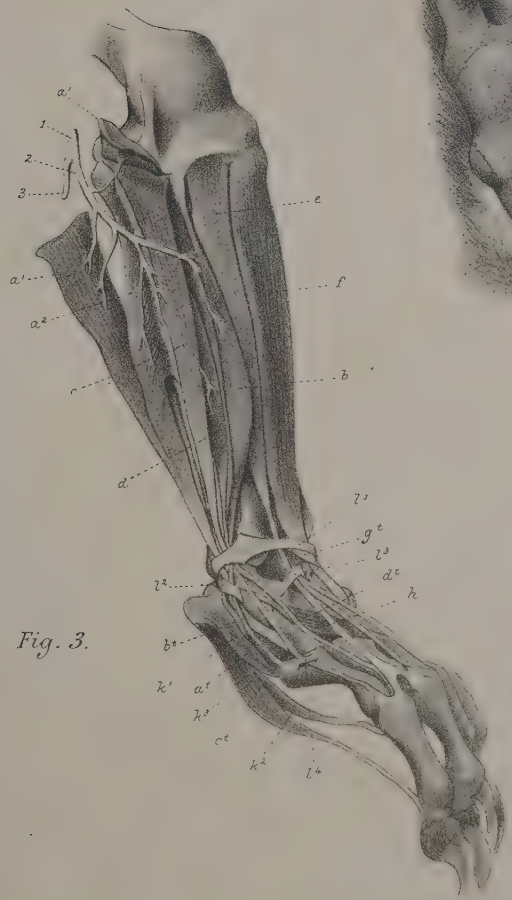


Fig. 3.

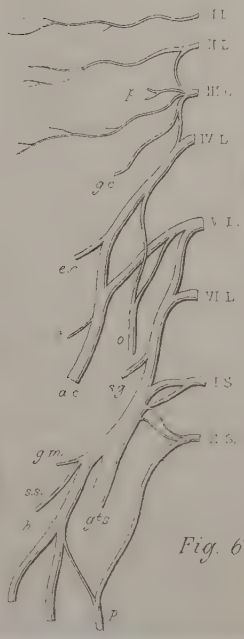


Fig. 6.

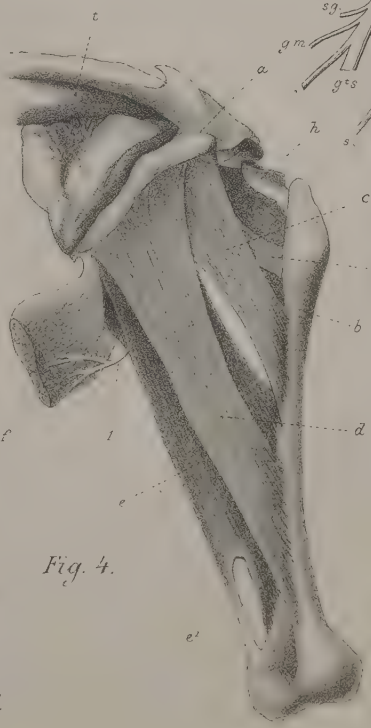


Fig. 4.

J. Dunlop Dunlop, del

F. Huth, Lith^r Edin^r

THYLACINE & CUSCUS.

Fig. 1.

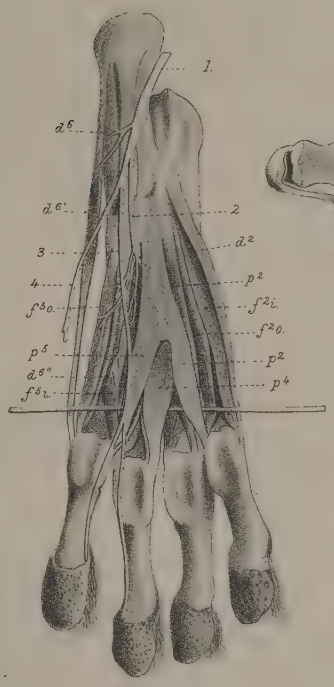


Fig. 5.

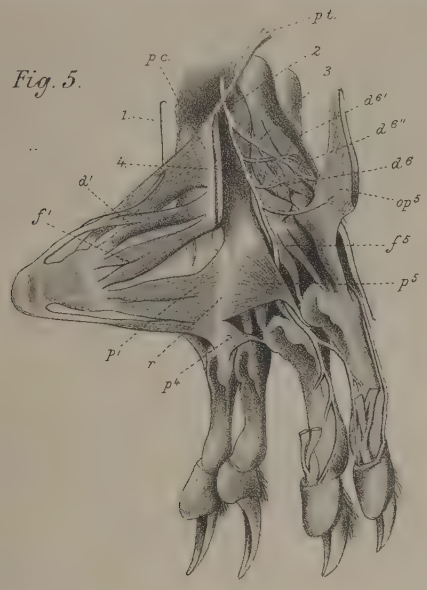
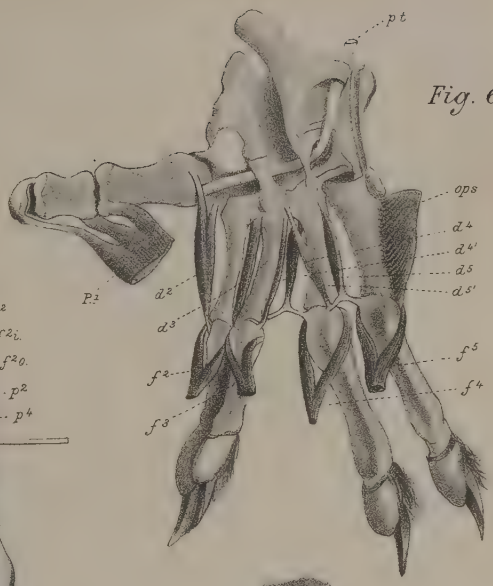


Fig. 6.



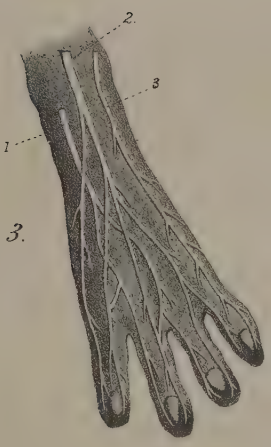


Fig. 3.

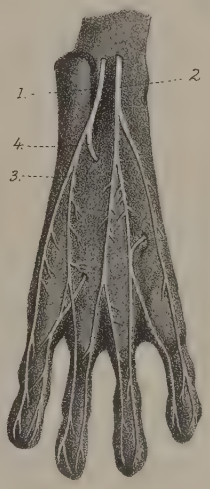
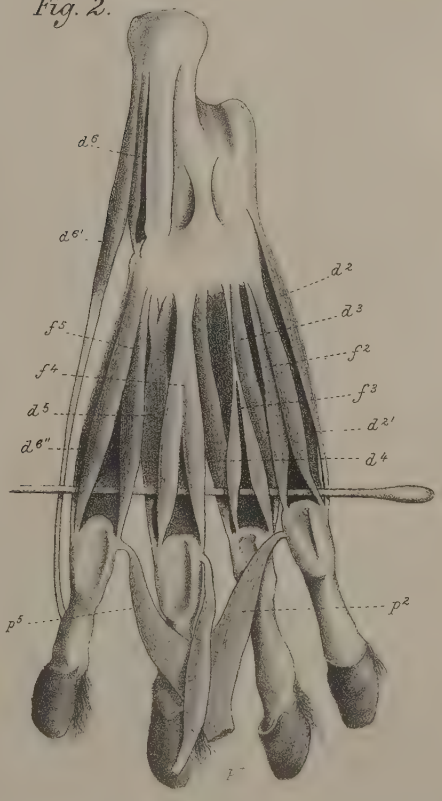


Fig. 4.

Fig. 2.



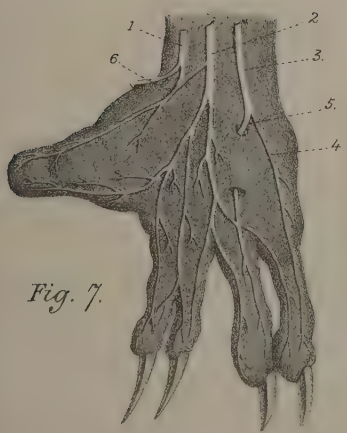


Fig. 7.

Fig. 8.

J. Dunlop Dunlop, del.

F. Huth, Lith. Edin.

THYLACINE & CUSCUS.

Fig. 2.

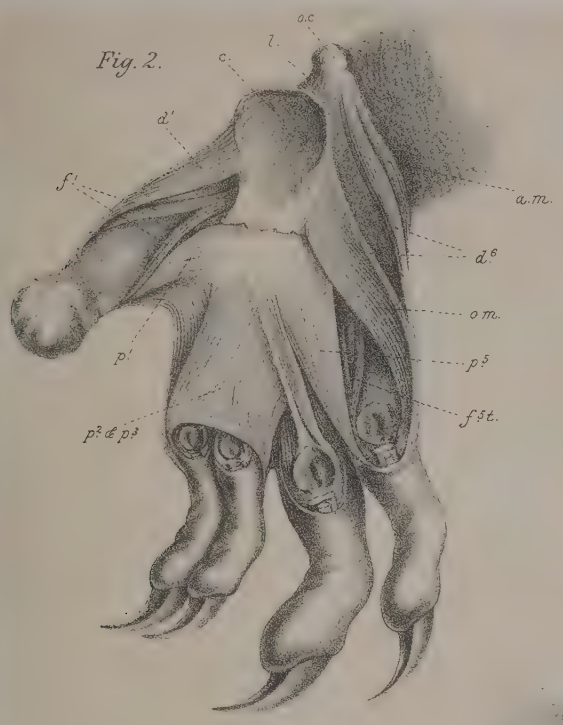


Fig. 3.

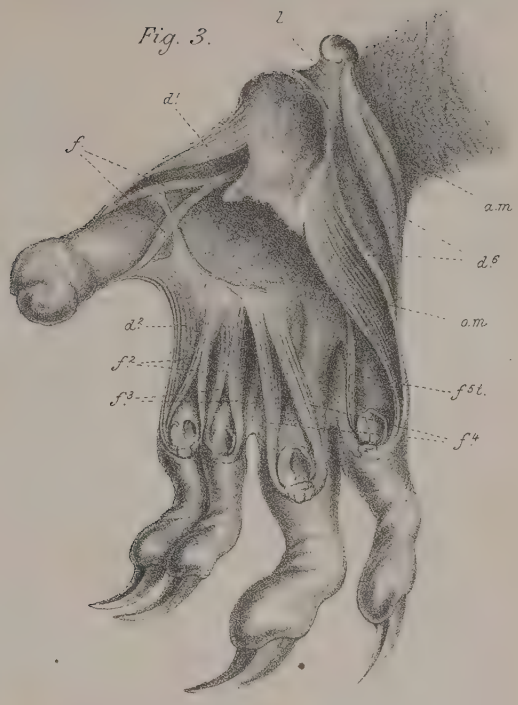


Fig. 1.

Fig. 4.

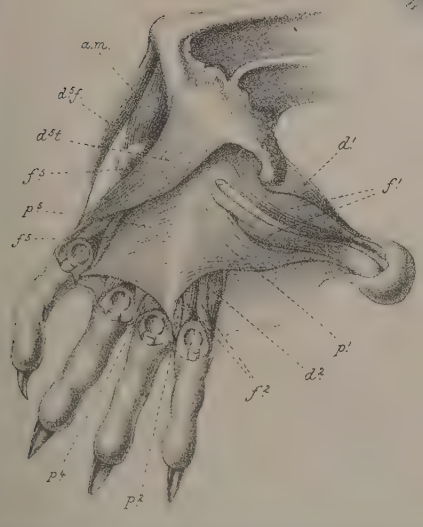


Fig. 5.

A. H. Young, del.

F. Huth, Lith.r Edin.r

PHASCOLARCTOS CINEREUS. — DIDELPHYS VIRGINIANA.

Fig. 1.

Fig. 2.

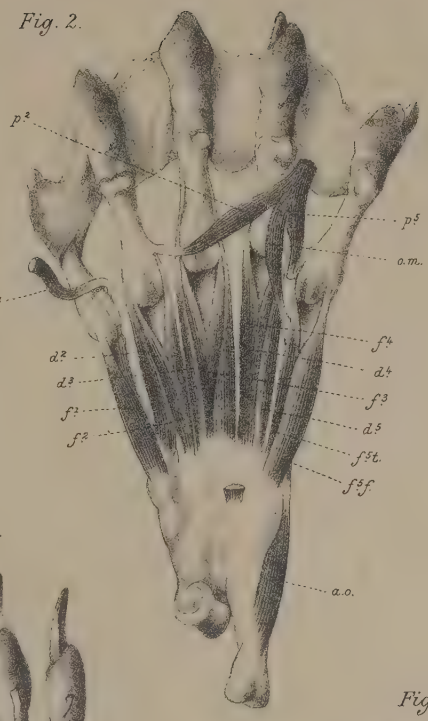


Fig. 3.

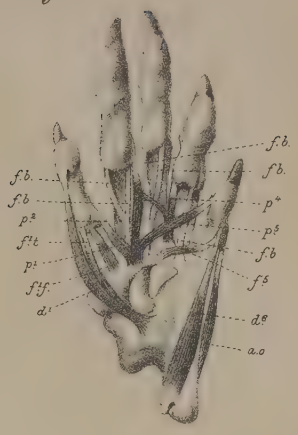


Fig. 4

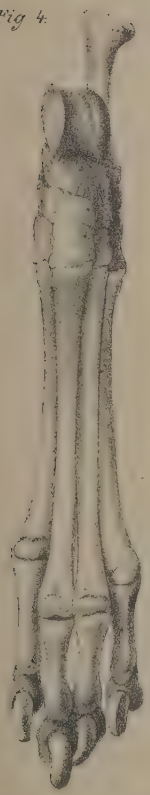


Fig. 5.

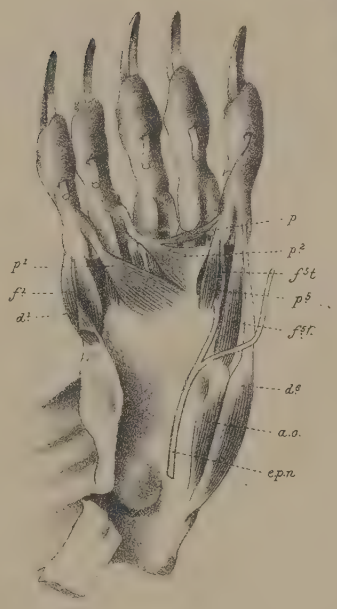


Fig. 6.

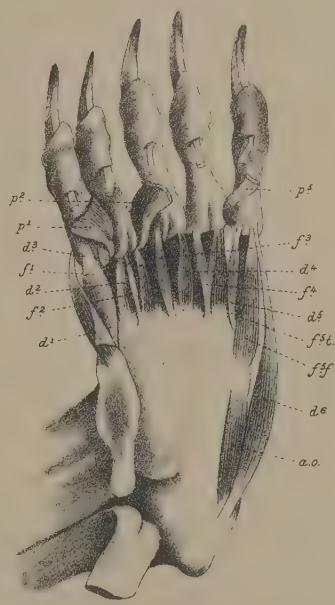


Fig. 7.

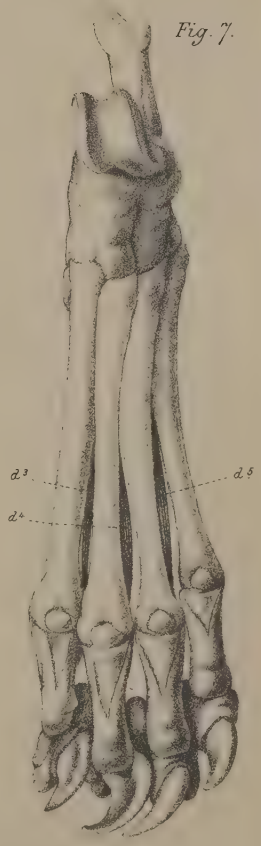
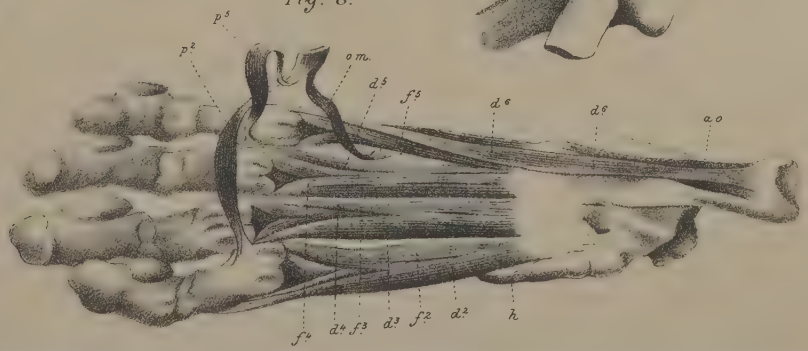


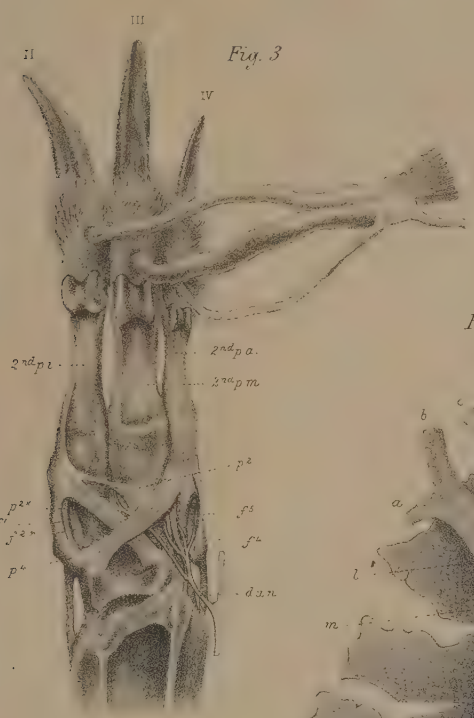
Fig. 8.

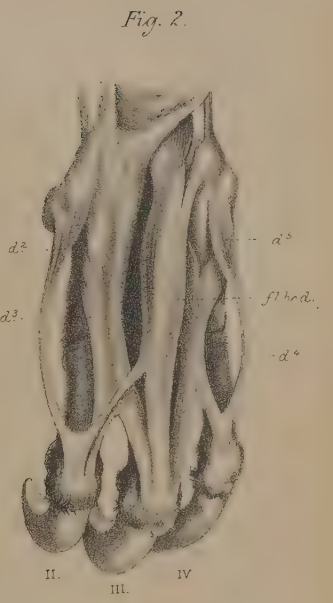


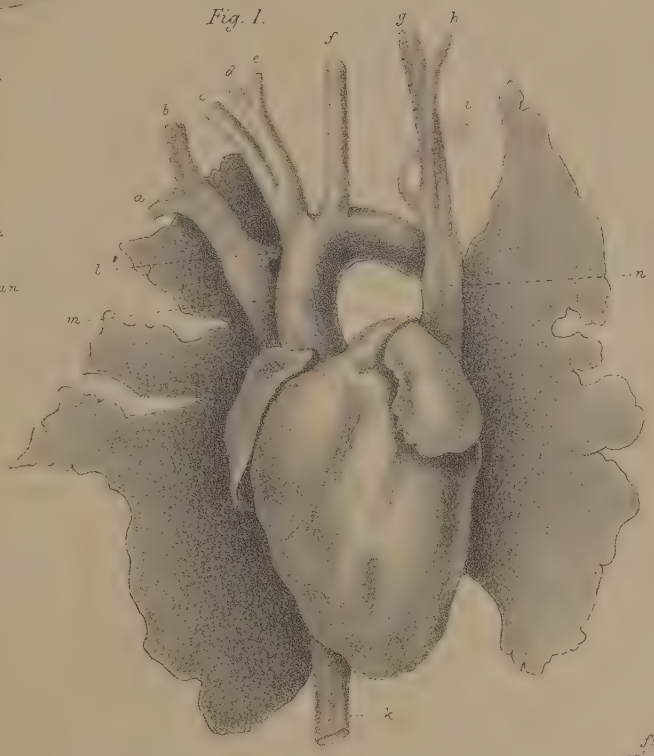
J Dunlop Dunlop. del

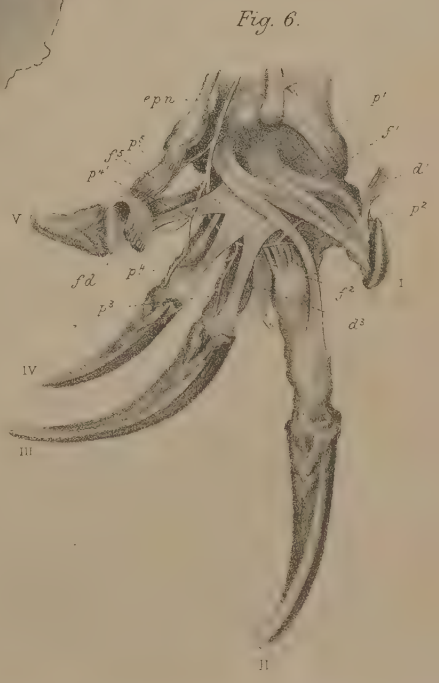
F Huth. Lith^r Edin^r

FEET OF VARIOUS MAMMALS.









Arthur Thomson, M.B. del.t F. Huth, Lith.r Edin.r

FIG. 1, THORACIC VISCERA OF THYLACINE. — FIG. 2-7, FEET OF VARIOUS MAMMALS.

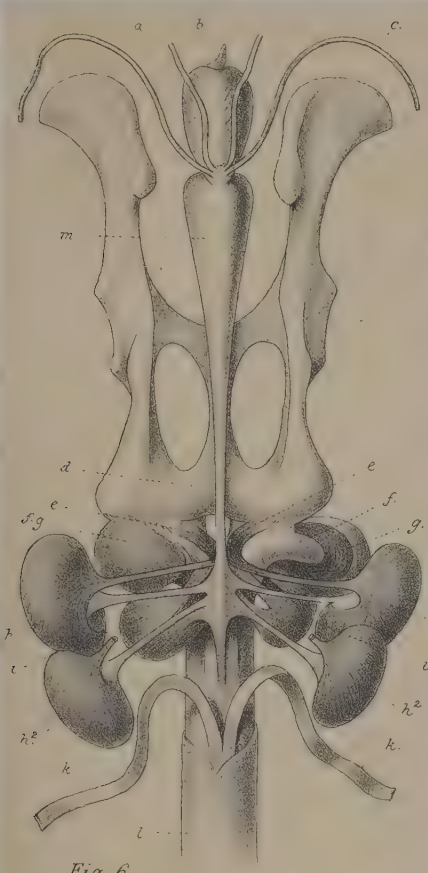


Fig. 6.

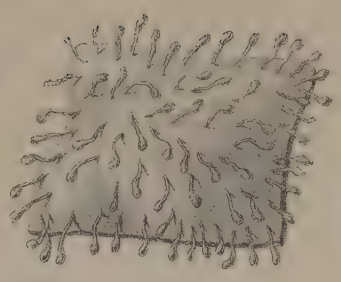


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 7.

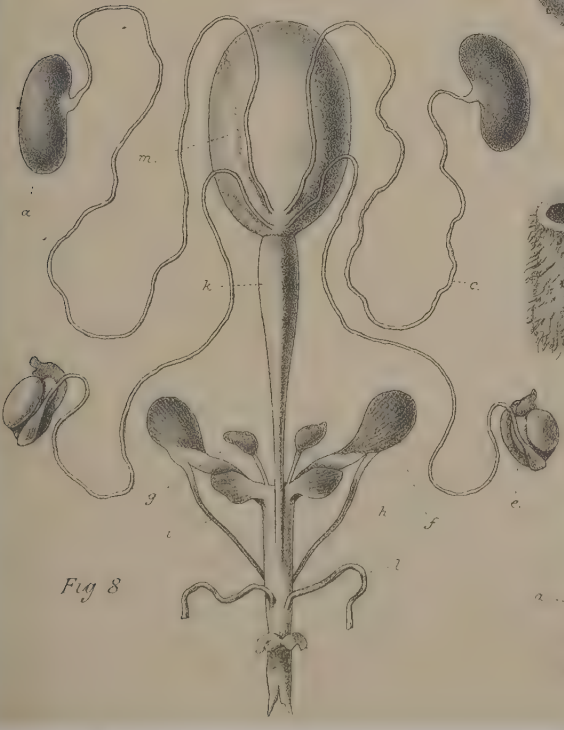


Fig 8

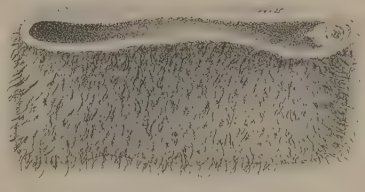


Fig. 5.

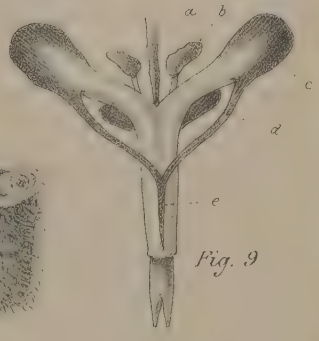
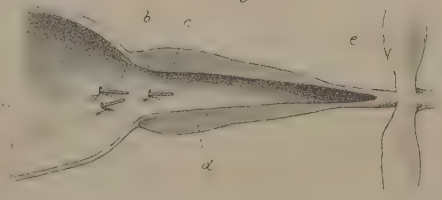


Fig. 9

Fig. 10.



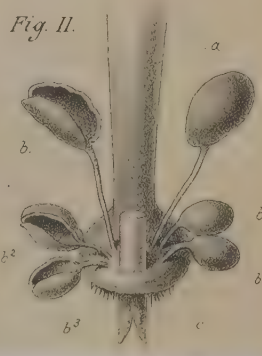
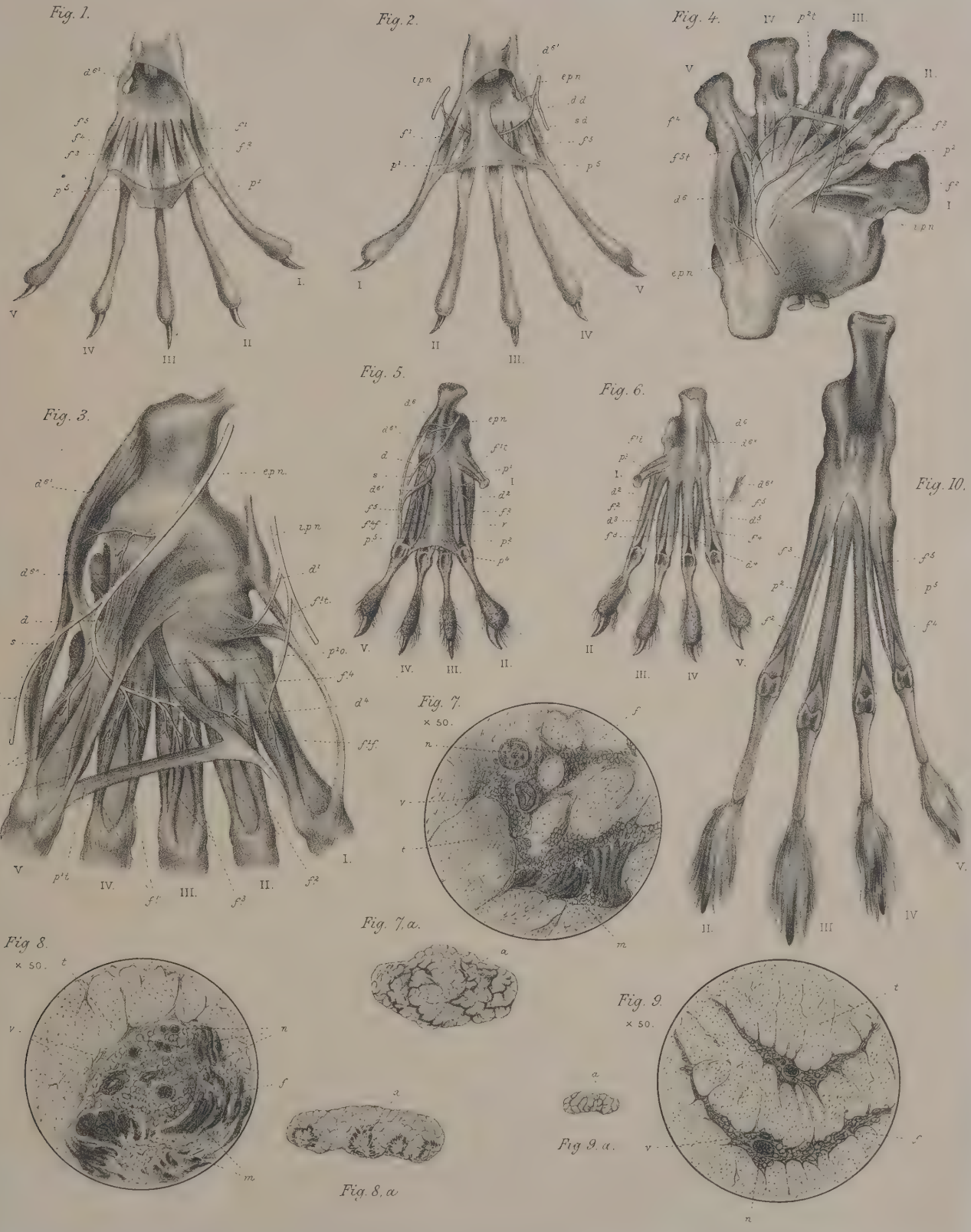


Fig. II.



Arthur Thomson, M.B. del.

F. Huth, Lith^r Edin^r

FIG. 1-6, & FIG. 10, FEET OF VARIOUS MAMMALS.
FIG. 7-9, STRUCTURE OF SUSPENSORY LIGAMENT IN HORSE, OX & SHEEP.

Fig. 6.

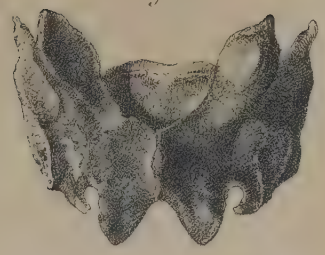
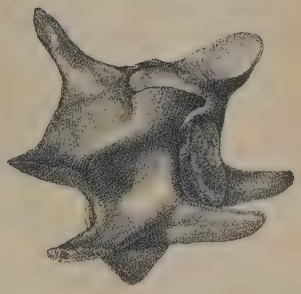


Fig. 2.

Fig. 3.



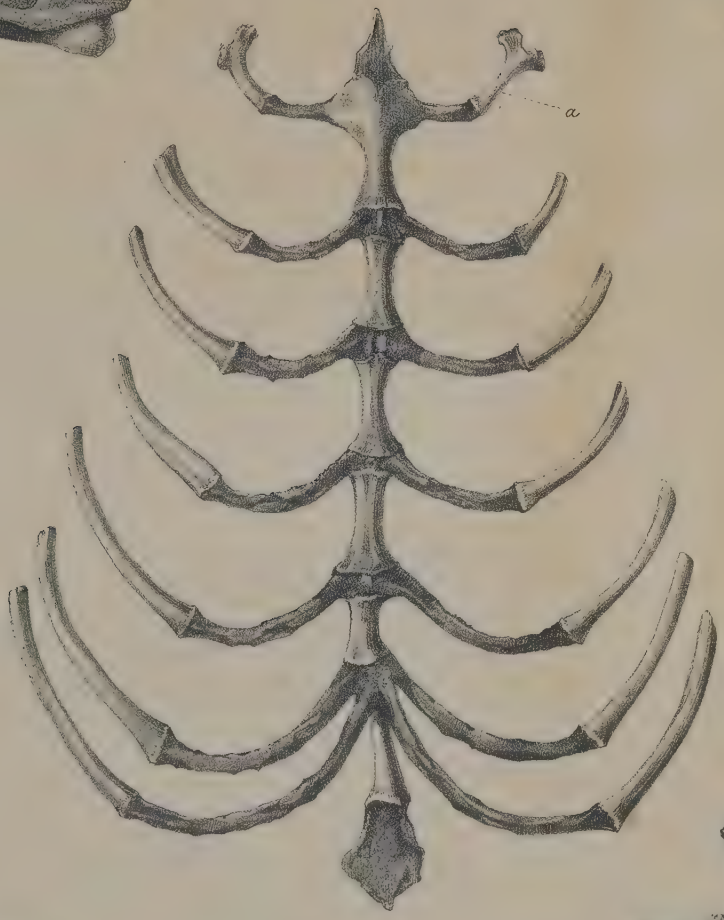


Fig. 4.

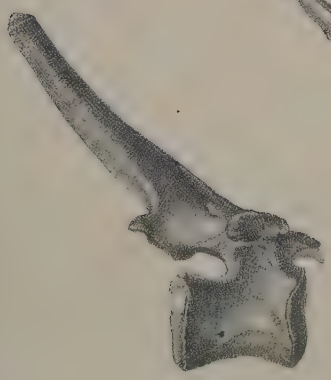


Fig. 5.

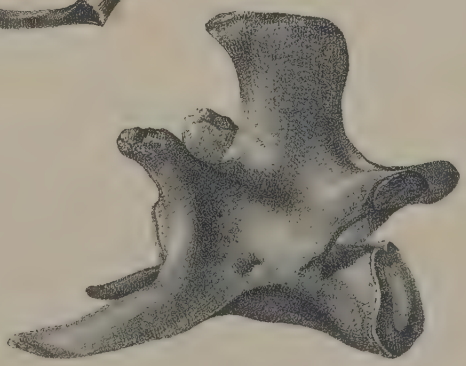


Fig. 1.

T. Lauder Sawers del.

F. Huth, Lith.r Edin.r

THYLACINE.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

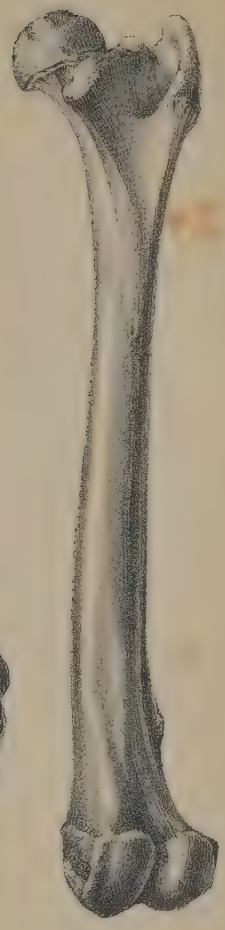
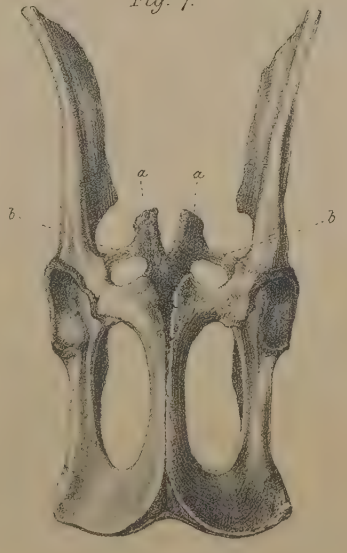


Fig. 5.

Fig. 6.

Fig. 7.



T. Lauder Sawers del. F. Huth, Lith. Edin.r

THYLACINE.

AUG 1956
LIBRARY
POFI
FISH & WILDLIFE
SERVICE